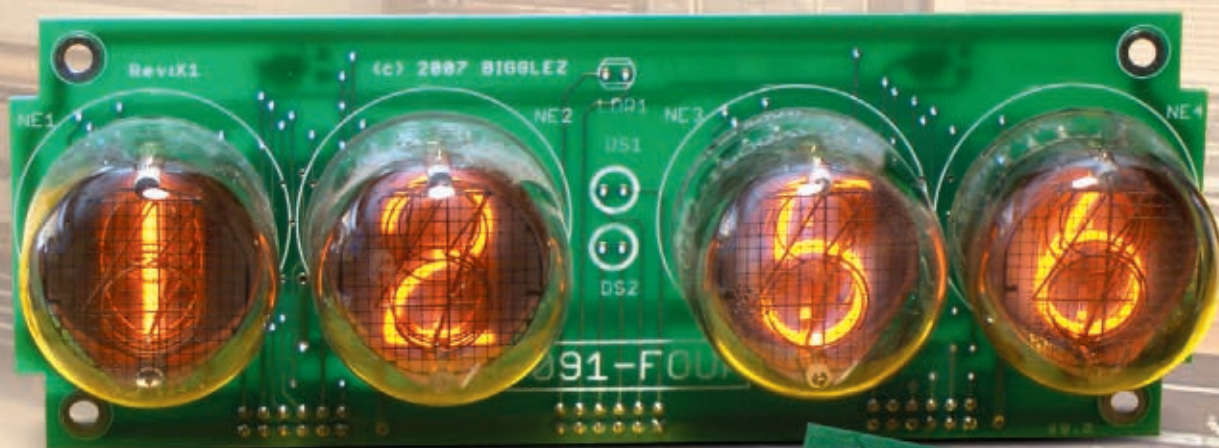


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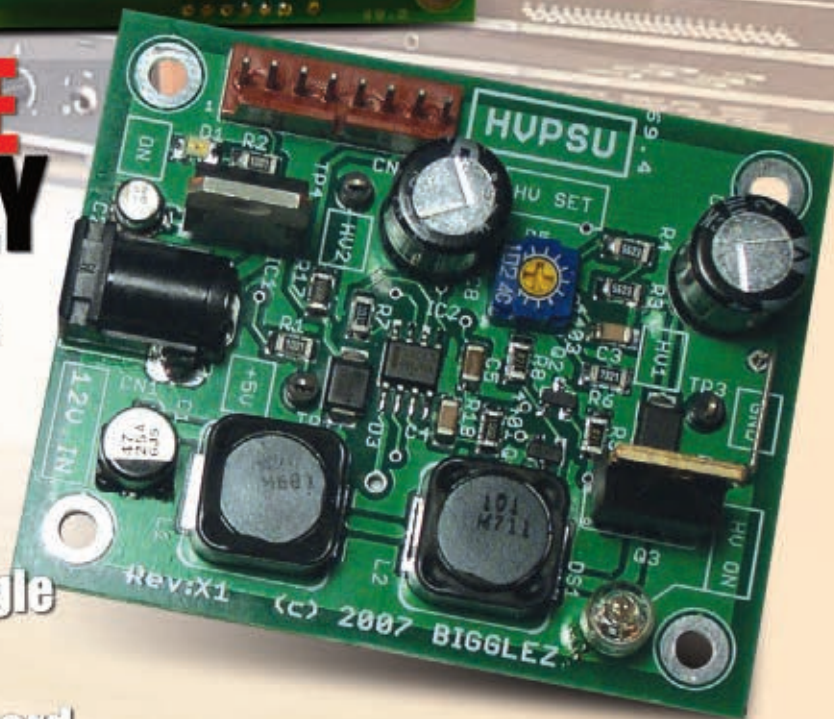


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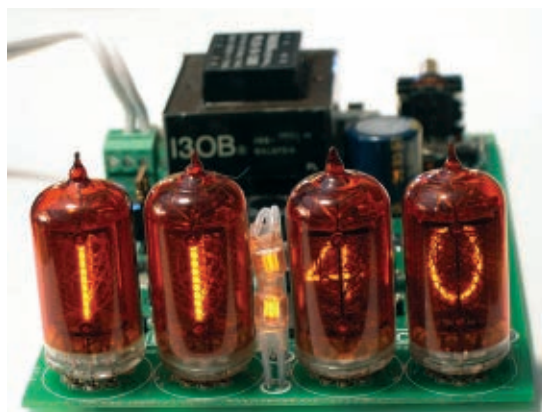
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Projects

32 HIGH VOLTAGE POWER SUPPLY UNIT

Build this stable HVPSU using a mix of old and new technologies that you can incorporate into other projects as a module.

■ By Peter Stonard



●●●● Advanced Level



●●●● Intermediate Level

44 HOUSEHOLD THERMOSTAT AND HEATING/COOLING CONTROL

This is a PIC-based project which will allow you to truly take control of your household environment. The unit is very intuitive and keeps track of tons of "cool" info.

■ By Chuck Irwin

Be sure to check the Nuts & Volts website for downloads that go along with these projects.

Review

39 REVIEW OF THE NIAGARA IV INK FLOW SYSTEM

Digital photography has streamlined the process of reproducing photos. However, prints are still costly to make. One way to reduce costs is to "roll your own" when it comes to ink tanks. This Niagara system lets you add external tanks to your own existing ink jet printer.

■ By Michael Simpson



Get ready for upcoming digital camera projects!

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54 DESIGNERS GUIDE TO RELIABLE OSCILLATORS AND TIMERS

Understanding and designing with the ever-useful CMOS timer.

■ *By Norm Looper*

60 ACCESS SERIAL PORTS WITH VISUAL BASIC .NET

Say you have a microcontroller circuit that needs to talk to a PC. A serial port is perfect for this type of application. But what if your computer doesn't have a serial port? No problem! Visual Basic lets you access USB/serial port adapters and virtual serial ports.

■ *By Jan Axelson*

67 HOW TO TRICK AN OP-AMP

Operate an op-amp on a single polarity supply, even though it wants to see both a positive and a negative voltage.

■ *By Richard Schroeder*



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74 TAMING WALL WARTS

Lurking around your home are devices that are constantly drawing current unbeknownst to you that result in needless power drain. Don't be alarmed! There are some things you can do to minimize this waste of energy.

■ *By Kenton Chun*

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A preview of the new DigienCabulator.

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Bird feeding monitor, eight bit binary counter, low battery cut-off circuit, more.

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Welcome to the land of CPLD.

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Sharpening Your Tools of Creativity

Getting started with stripboard circuit construction.



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by Bryan Bergeron, Editor

DEVELOPING PERSPECTIVES

What Price for Perfection?

Most of the articles featured in *Nuts & Volts* cater to the frugal engineering types — readers who carefully consider cost versus quality when selecting components and subsystems. But there is another breed of electronics enthusiast — the experimental audiophiles who are drawn to the very best, with little regard to price. Vendors that cater to this segment of the market feature \$300/meter palladium clad, oxygen-free cables, solid silver and gold connectors, and component audio systems that feature, for example, \$6,000 “reference” preamps.

When you walk into a showroom that caters to audiophiles, it’s easy to be impressed by massive speakers, rare metal cables and connectors, and the solid, hefty feel of superbly designed audio gear. That said, how does one rationalize spending \$10,000 for an amp or \$6,000 for a preamp, when the cost per gram approaches that of 24K gold? There is, of course, a premium extracted by the vendor for high-end, name brand, hand-assembled electronics. However, with the exception of exotic power and speaker cables, it’s not all marketing. If you pop the cover on an audiophile amp or preamp, odds are you won’t see typical components. Power supplies tend to be massive, over-designed affairs with huge banks of expensive electrolytic capacitors and specially wound toroidal transformers. The tubes and discrete active components may be hand matched. Even something as simple as a volume control suddenly takes on new meaning. Instead of a \$2 Alpha or RadioShack potentiometer, you’ll likely find a \$45 ALPS potentiometer (see Figure 1) or even a \$200 DACT or GoldPoint stepped attenuator.

From a project development perspective, are audiophile quality components worth it? After all, if you’re going to invest a weekend or more on a project, why not go for the best components possible, instead of finding the best deal in a discount parts bin? Is there a real

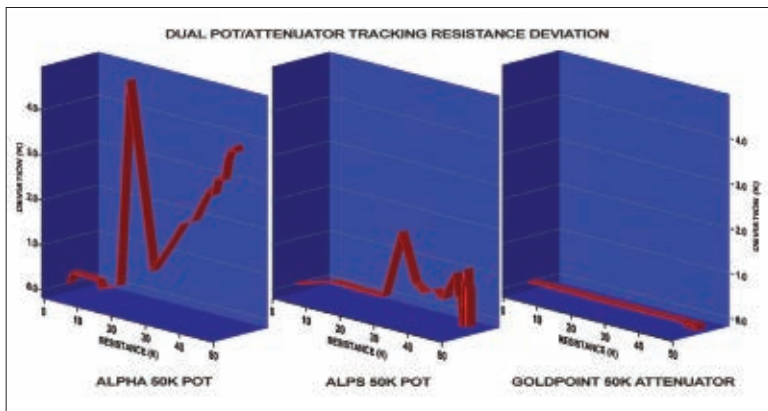
difference? From a purely electrical perspective, it’s often an easy task to differentiate components. Take the significance of the tracking accuracy of stacked potentiometers, for example. Figure 2 shows the tracking accuracy of stacked audio taper pots from Alpha and ALPS, and a stepped attenuator from GoldPoint. I measured resistances with a recently calibrated Fluke 45 DMM at room temperature. From the figure, you can see that there is virtually no difference between the resistance provided by each stack in the GoldPoint step attenuator from the range of 0-50K. That is, when the attenuator is at midpoint, both stacks — say, left and right volume control resistance — present exactly the same resistance, within the measurement capabilities of my DMM. The less expensive ALPS potentiometer has a maximum resistance difference of about 1.5K, with most of the difference noted above about 25K. The inexpensive Alpha potentiometer shows the greatest deviation in resistance between its stacked potentiometers, with a maximum of about 5K to around 21K.

There are also practical differences between the expected longevity of audiophile and commodity components. For example, if you look through your Mouser or Jameco catalog, you’ll find that many components are categorized by accuracy of value, longevity at a certain temperature, or use. Garden-variety potentiometers are typically rated at 10,000 turns. That’s one turn per day for about 27 years. In comparison, the GoldPoint step attenuator with gold-plated contacts is warranted for three years, regardless of use level.

Mean time before failure (MTBF), size, weight, thermal stability, resistance to caustic elements in the environment, and similar hard measures aside, in evaluating components, there is the issue of psychophysics

FIGURE 2. Stacked audio taper potentiometer tracking for Alpha Potentiometer, ALPS Potentiometer, and GoldPoint Stepped Attenuator.

FIGURE 1. ALPS audiophile-quality potentiometer.



— the relationship between physical stimuli and perception. In the case of stacked potentiometers or stepped attenuators, one psychophysical issue is whether the relative difference in resistance is noticeable. Most of us can detect a 3 dB change in volume, and someone with an exceptionally good ear can detect differences of about 1 dB. However, without details of the circuit controlled by each of the pots/attenuator in Figure 2, it's difficult to determine whether the differences in resistance would result in detectable differences in volume. Certainly, given the same stereo amplifier circuit, the GoldPoint step attenuator and ALPS potentiometer are less likely to cause a noticeable difference in output than is the Alpha potentiometer.

Another psychophysical factor to consider when evaluating audiophile-grade components is feel. A stepped attenuator bolted to a quarter-inch thick aluminum front panel and attached to a solid aluminum knob simply feels better to the touch than a \$2 pot affixed to a flimsy front panel and attached to a plastic knob. Whether you're willing to pay five or ten times more for audiophile-quality feel is a personal decision. Car enthusiasts don't buy chrome-plated engine parts for increased performance.

If you take the time to familiarize yourself with audiophile designs and components, you'll open new possibilities in your design and repair repertoire. You'll also be better prepared to spot quality audio components and gear on eBay. And if you've designed audiophile circuits, please consider sharing your work with your fellow readers. **NV**

Alpha Potentiometers — www.alphapotentiometers.net

ALPS Potentiometers — www.alps.com

GoldPoint Stepped Attenuators — www.goldpt.com

DACT Stepped Attenuators — www.dact.com/html/attenuators.html

Student Develops New LED, Wins \$30,000 Lemelson-Rensselaer Prize

In recent years, light emitting diodes (LEDs) have begun to change the way we see the world. Now, a Rensselaer Polytechnic Institute student has developed a new type of LED that could allow for their widespread use as light sources for liquid crystal displays (LCDs) on everything from televisions and computers to cell phones and cameras.

Martin Schubert, a doctoral student in electrical, computer, and systems engineering, has developed the first polarized LED, an innovation that could vastly improve LCD screens, conserve energy, and usher in the next generation of ultra-efficient LEDs. Schubert's innovation has earned him the \$30,000 Lemelson-Rensselaer Student Prize. Schubert is the second recipient of the Lemelson-Rensselaer award. The prize, which was first given in 2007, is awarded to a Rensselaer senior or graduate student who has created or improved a product or process, applied a technology in a new way, or otherwise demonstrated remarkable inventiveness.

Schubert's polarized LED advances current LED technology in its ability to better control the direction and polarization of the light being emitted. With better control over the light, less energy is wasted producing scattered light, allowing more light to reach its desired location. This makes the polarized LED perfectly suited as a backlighting unit for any kind of LCD, according to Schubert. Its focused light will produce images on the display that are more colorful, vibrant, and lifelike, with no motion artifacts.



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The image shows a robotic arm with a vacuum gripper picking up a small red component from a black surface. The background is a gradient of red and orange with yellow arrows indicating movement. A circular inset shows a hand holding a small electronic component.

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"N"TERESTING DILEMMA

I have some questions regarding the Four Transistor Metal Detector project from the February '08 issue. I'm a hobbyist, not an engineer, but I've never seen "nF" capacitors used anywhere else and cannot find them listed in Jameco or RadioShack (my normal sources of parts). All of the resistors except R12 are 1/4 watt which leads me to ask if the circuit needs a 1W resistor there? Finally, the only 56 pF 100V capacitor I can find in Jameco's catalog is an SMT — is that correct?

Jim Hicks (Fernandia, FL)

A 1 nF capacitor is 1 nanofarad which is equal to 1,000 pF or .001 μ F. So C1, a 100 nF device, is the same as 0.1 μ F. You may be unfamiliar with this power of ten notation because it is more commonly used in Europe. R12 contains a typo in its description and should be 1/4W. It took some searching, but Jameco does sell a 56 pF non-SMT capacitor that can be used for C2; part number 1132478. — Ed

JUST CAN'T RESIST

I was thrilled to read "The Design Cycle" (Managing the Real World, by

Fred Eady) in the January '08 issue. I found this month's topic fascinating and very pertinent to my interests in PIC circuits. I have a couple of specific questions regarding Schematic 2 on page 84. Mr. Eady does not mention the functional purpose for the 1N5189 diode and the 10K resistor. Is the diode there to route the reverse voltage that could occur from the collapsing magnetic field of the solenoid? If so, why is it not required in Schematic 3 for the UDK2559 device? And what is the reason for including the 10K resistor? In similar PIC microcontroller interface circuits, when I have used a bipolar transistor instead of his suggested MOSFET, I have not designed a resistor in that location.

Judy May, W1ORO (Union, KY)

I'm very pleased that you enjoyed the subject matter. So, let's see if I can answer your questions. The 1N5189 is really "insurance." Most modern MOSFETs contain a body diode that is reverse-biased against the MOSFET drain and source. In this case, the ZVN4306G datasheet does not directly show or mention an integral body diode. Thus, the reason for the "insurance policy" 1N5189.

continued on page 96

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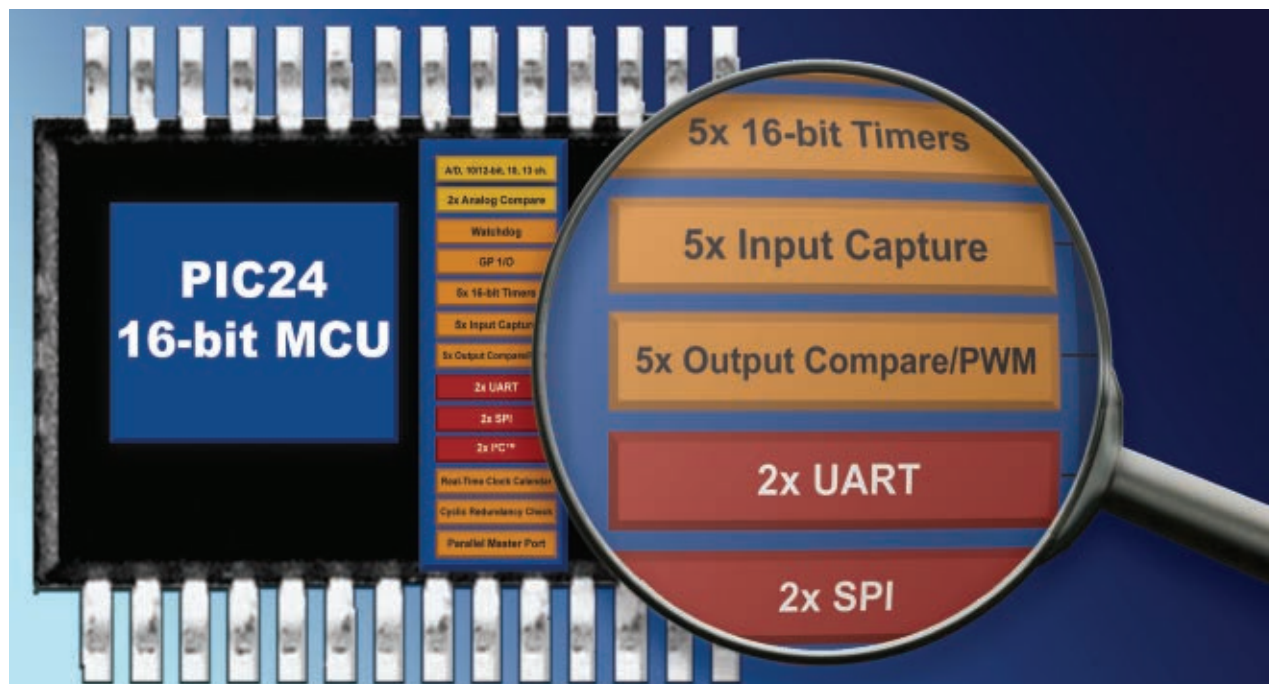


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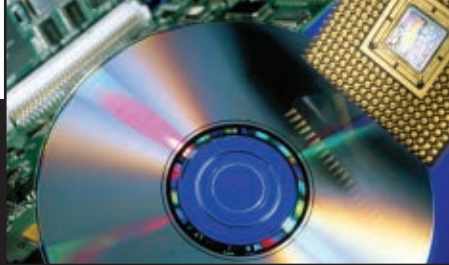
Device	Pins	RAM (KB)	Flash (KB)	Features include up to:
PIC24FJ16GA002	28	4	16	5x 16-bit Timers
PIC24FJ16GA004	44	4	16	5x Output Compare/PWM
PIC24FJ32GA002	28	8	32	5x Input Capture
PIC24FJ32GA004	44	8	32	Real Time Clock Calendar
PIC24FJ48GA002	28	8	48	2x UART
PIC24FJ48GA004	44	8	48	2x SPI
PIC24FJ64GA002	28	8	64	2x I2C™
PIC24FJ64GA004	44	8	64	Parallel Master Port
PIC24HJ12GP201	18	1	12	2x Analog Comparators
PIC24HJ12GP202	28	1	12	10/12-bit ADC



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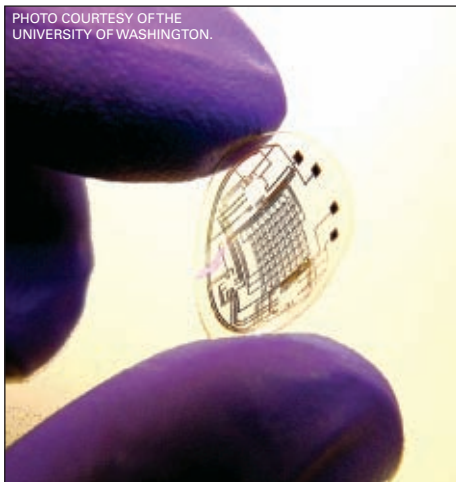
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■ BY JEFF ECKERT

ADVANCED TECHNOLOGY

IN THE EYE OF THE BEHOLDER — LITERALLY



■ A researcher holds a prototype bionic lens.

Head-mounted and other virtual displays are nothing new, but they usually are noncontact entities. Now engineers at the University of Washington (www.washington.edu) are developing what may turn out to be a major contribution to “information overload:” contact lenses imprinted with electronic circuits and lights. The goal is to allow the wearer to see a generated image super-imposed over the outside world. Researchers cite many possible uses, including navigation information for drivers or pilots, virtual reality for video games, and Internet surfing while you go about your daily business. According to researcher Babak Parviz, “People may find all sorts of applications for it that we have not thought about. Our goal is to demonstrate the basic technology and make sure it works and that it’s safe.”

The prototype, introduced in January at the IEEE International Conference on Micro Electro-Mechanical Systems, contains an

electrical circuit plus some red LEDs, although the display does not yet light up. The lenses have been tested on rabbits for up to 20 minutes, and they apparently suffered no ill physical effects. Fully operational versions are not expected to obstruct the wearers’ vision, either, as “there is a large area outside of the transparent part of the eye that we can use for placing instrumentation.” Future incarnations may include wireless communications to and from the lens, embedded solar cells for power, and even optical correction.

The concept is fascinating but seems to have some potential drawbacks. If you think the highways are dangerous now, picture Granny driving down the interstate, talking on the cell phone, smoking a Raleigh, and watching Jerry Springer with her bionic eyes — with a turn signal on and her seat belt buckle dragging on the pavement, making sparks. This isn’t necessarily a good thing.

NAVY DEMONSTRATES RAILGUN TECHNOLOGY



■ Firing of the Navy’s electromagnetic railgun — frame captured by a high-speed video camera.

The concept of a railgun is nearly bonehead simple: You drop the

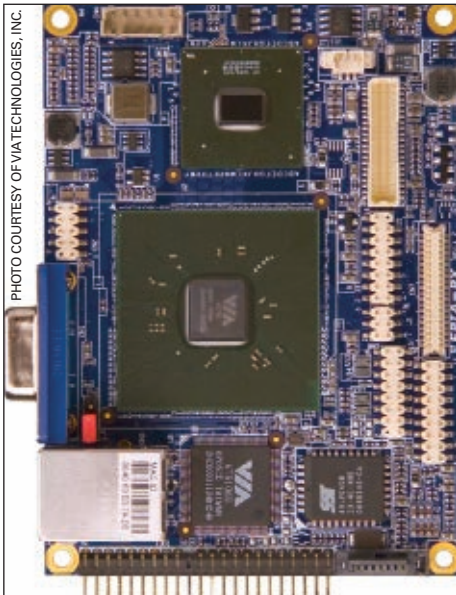
slug on a pair of electrified metal rails and it completes a circuit, becomes an electromagnet, and slides away from the power supply end toward the launch end. It’s relatively safe to operate, as no chemical propellants are involved, and the projectile destroys its target with sheer velocity rather than an explosive charge. Among the drawbacks is the heat generated in the process, which tends to erode the rails pretty quickly, and the pulse power supply and launcher pose major design challenges. Plus, it’s not much good for squirrel hunting.

Nevertheless, in January, the Navy put on a record-setting demonstration of its test unit. Using 10.64 MJ of power (equivalent to about 3 kW/hr of electricity), operators fired off a (reportedly) 7 lb slug at a muzzle velocity of 8,268 ft/s (2,520 m/s) and sent it crashing through a target at a facility in Dahlgren, VA. When full capability is achieved (scheduled for 2016 to 2018), the gun will be able to send a projectile 200+ nautical miles at mach 7, allowing it to strike the target at mach 5. In comparison, the Navy’s current MK 45 5 in gun has a range of only about 13 nautical miles.

Commenting on the demonstration, Chief of Naval Operations Adm. Gary Roughead, said, “We should never lose sight of always looking for the next big thing, always looking to make our capability better, more effective than what anyone else can put on the battlefield. I never ever want to see a Sailor or Marine in a fair fight. I always want them to have the advantage.”

COMPUTERS AND NETWORKING

BUILD YOUR OWN PEEWEE PC



■ A VIA EPIA PX-Series Pico-ITX board.

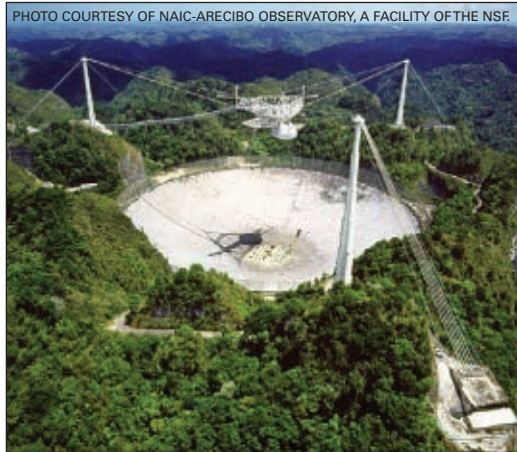
If you have been frustrated by off-the-shelf computers that suffer from poor quality and sloppy workmanship, never fear! You now have an opportunity to screw one up all by yourself. VIA Technologies (www.via.com.tw), a provider of x86 silicon and platform products, recently launched VIA ARTiGO, a build-it-yourself ultra-compact PC kit.

Designed by the creators of the Pico-ITX form factor, the VIA ARTiGO Builder Kit provides all of the components necessary to create a reasonably robust machine that fits in a 5.9 x 4.3 x 1.8 in (15 x 11 x 4 cm), 1.14 lb (520 g) package. You get a VIA EPIA PX10000 Pico-ITX board, chassis, power adapter, and other essential accessories, including cabling and port accessories. You just add your choice of system memory, a hard drive, and an operating system (Windows 2000/XP, WinCE, XPe, or Linux) and you're ready to go.

The powerboard has been designed for low power draw, with a system consuming around 15 W in idle, while the mainboard consumes a maximum of 20 W under full load. It runs a 1 GHz VIA C7 processor

and supports up to 1 GB of DDR2 system memory. You get 10/100 Fast Ethernet, a VGA monitor port, four USB 2.0 ports, and two audio jacks. The retail price is \$300.

JOIN THE SEARCH FOR ET



■ Aerial view of the Arecibo facility.

You are probably aware of the Search for Extraterrestrial Intelligence (SETI) Institute, founded in 1984 to "explore, understand, and explain the origin, nature, and prevalence of life in the universe." But you may not have heard of the SETI@home project. This is not actually a project of the SETI Institute, but there is a connection in that the Institute supports UC Berkeley's Project SERENDIP (Search for Extraterrestrial Radio Emissions from Nearby Developed Intelligent Populations) which, in turn, provides SETI@home with data from the Arecibo Radio Telescope down in Puerto Rico. Or something like that. Never mind.

What's important is that SETI@home is an eight-year-old program designed to take advantage of unused PC processing cycles to help crunch the numbers coming in from Arecibo. At present, about 320,000 home computers are part of the network.

Because the Arecibo

■ ThingMagic's RFID system has been adopted by Ford and DEWALT.

telescope has just been upgraded with seven new receivers that allow it to record signals from seven sky regions simultaneously, the data flow has increased to about 300 GB/day, and SETI@home needs many more volunteers. If you want to sign up, all you have to do is download and install the software, which is basically a screen saver that performs the analytical work while giving you a glimpse of what's going on from the SETI@home website. Then, whenever your PC is just sitting there twiddling its digits, it can receive a 300 kB chunk of SERENDIP data, analyze it, and send back the results. To get started, visit setiathome.ssl.berkeley.edu/. Who knows? You may be among the first to process reality TV programming from the Sagittarius Dwarf.

CIRCUITS AND DEVICES

TRACK YOUR TOOLS AUTOMATICALLY

Once upon a time, a pickup truck was a pretty basic entity, generally sporting a stick shift, a marginally decent radio, and a modest price tag. About the only option anyone wanted was a gun rack. But today, they come with an array of luxury options that push the price tags up to \$40,000 or more. One of the latest (but at least practical) frills comes from ThingMagic (www.thingmagic.com), which recently announced a partnership with Ford Motor Co. (www.ford.com) and DEWALT



INDUSTRY AND THE PROFESSION

CLARKE WINS TURING AWARD

The Association for Computing Machinery (ACM, www.acm.org) provides 16 different awards for technical and professional achievements in computer science and information technology, and its A.M. Turing Award is perhaps the most prestigious in the field, often referred to as the Nobel Prize of computing. In January, it was announced that, for their groundbreaking work on an automated

method for finding design errors in hardware and software, Carnegie Mellon's Edmund M. Clarke and two colleagues had won the 2007 award.

The method, called "model checking," has been important in improving the reliability of complex computer chips, systems, and networks. Clarke will share the \$250,000 award with E. Allen Emerson of the University of Texas, who worked with him on the project. Also claiming a share is Joseph Sifakis of CNRS-Verimag Laboratory, who independently developed a similar technique. Financial support for the Turing award is provided by Intel and Google.

(www.dewalt.com) to equip 2009 F-150 and F-series Super Duty pickups and E-series vans with its embedded RFID asset tracking system. The reader system uses ThingMagic's Mercury5e module and a pair of antennas to enable Ford and DEWALT owners to track such tagged assets as tools, construction equipment and materials, and so forth. This allows better asset tracking and inventory control, and helps ensure that the crew won't drive 50 miles to the job site only to discover that essential tools and materials are missing. You can even tag Bubba the hound carrier to avoid leaving him at the Waffle House after lunch.

The system is part of Ford's Work Solutions collection of productivity tools, which also includes an on-board PC, a Bluetooth speakerphone, the theft-preventive Cable Lock System, and other items. No price tag was mentioned in various press releases, but it will run you considerably more than a pair of fuzzy dice.

CUT-RATE AUV

We recently ran across an interesting little swimbot, the Iver2 autonomous underwater vehicle (AUV). Built by OceanServer Technology, it is a lightweight (42 lb, or 19 kg) unit designed for coastal operations such as environmental monitoring, hydrographic surveying, and homeland defense. According to



■ Several Iver2 variations ready to launch.

the company, it is the first such AUV to be priced at less than \$50,000, which is still out of range for hobbyists, but dirt cheap by commercial and military standards. In fact, the Naval Oceanographic Office has two of them in operation, equipped with side scan sonar and chemical sensors for monitoring water quality.

Standard features include point-and-click mission planning using standard charts from NOAA, USGS, or satellite images; an embedded Windows XP-based platform; operations down to 300 ft (90 m) below the surface; and the ability to be shore launched by one person. Specifications include 49.8 in (1.3 m) length by 5.8 in (0.15 m) diameters (without sensors), 10 hr endurance powered by rechargeable lithium-ion batteries at 2.5 kt, and a maximum speed of

4 kt. Navigation is by dead reckoning (or differential GPS when on the surface). The onboard electronics are based on a low-power x86 processor and an 80 GB drive for data collection. You can add an emergency airbag recovery system, an upgraded CPU card, and a GPS/WiFi surface tow float. Spec sheets and other literature can be downloaded from www.iver-auv.com.

SWITCHES HAVE NO MOVING PARTS

A new technology that was impressive enough to win a 2007 ECN Readers Choice award is the ActiveMetal™ series of switches from ITW Switches (www.itwswitches.com). These touch-sensitive devices have no moving parts and as a result are rated for 100+ million cycles. Their unusual operation is based on the principle of acoustic resonance.

In operation, ultrasonic transducers set metallic trapped energy regions in the switch in motion in the MHz range, and a sensor monitors the vibrations' decay ("ring-down time"). When you press a finger on the front surface, it damps the vibration, thereby reducing ring-down time. The sensor detects the change and activates the switch. Shown in the photo are 19 mm aluminum alloy switches with Type II anodization and 5 VDC I/O. Either momentary or alternate action can be programmed. All of the ActiveMetal products are impervious to moisture, can be operated with gloved or unprotected hands, can withstand high levels of shock and vibration, and are not affected by electromagnetic radiation or ESD events up to 25 kV. The operating temperature range is typically -40° to 184°F (-40° to +85°C). **NV**

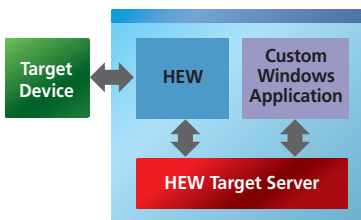
■ Different 19-mm aluminum alloy touch-sensitive switches.



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control builds and sessions, automate processes, and program target MCUs/MPUs. You can send and receive variables, set breakpoints and be notified of HTS events all through the existing debug interface. No additional USB or serial channels are required. Your application possibilities are endless with HTS. Use it to quickly automate testing, create virtual hardware, create user interfaces, view messages from your target micro, etc. Do whatever the situation requires and your imagination inspires! For more information on the HEW Target Server, visit America.Renesas.com/HTS.

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HEW TARGET SERVER

Design Contest 2008

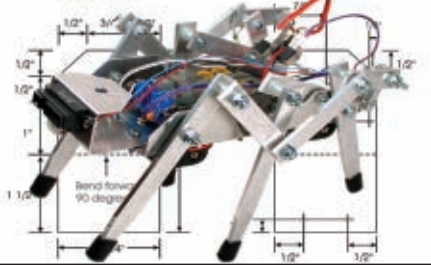
\$15,000
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ROBOTICS

PERSONAL

UNDERSTANDING, DESIGNING & CONSTRUCTING ROBOTS & ROBOTIC SYSTEMS

■ BY VERN GRANER

A PREVIEW OF THE NEW DIGIENCABULATOR

MANY OF US HAVE READ ABOUT (and drooled over!) some of the amazing gadgets the major names in robotics development have displayed over the last couple of decades. Just watching the DARPA Grand Challenge has shown us high-end "LADAR" laser range finders, massive multi-processor computers, and custom-written fuzzy logic based AI computer vision systems.

Schools like CMU and MIT have seven-digit budgets, gobs of space, and tons of components, not to mention the throngs of helpful energy-drink fueled students to assist on such projects. Whereas if you're like me, you're limited to devices you can afford after paying all the household bills and eating mac and

cheese for lunch every week. But, every once in a while, folks like us can catch a break and get access to some amazing technology that manages to filter down from the "big shots." I discovered such a device recently while investigating a new product from Parallax.

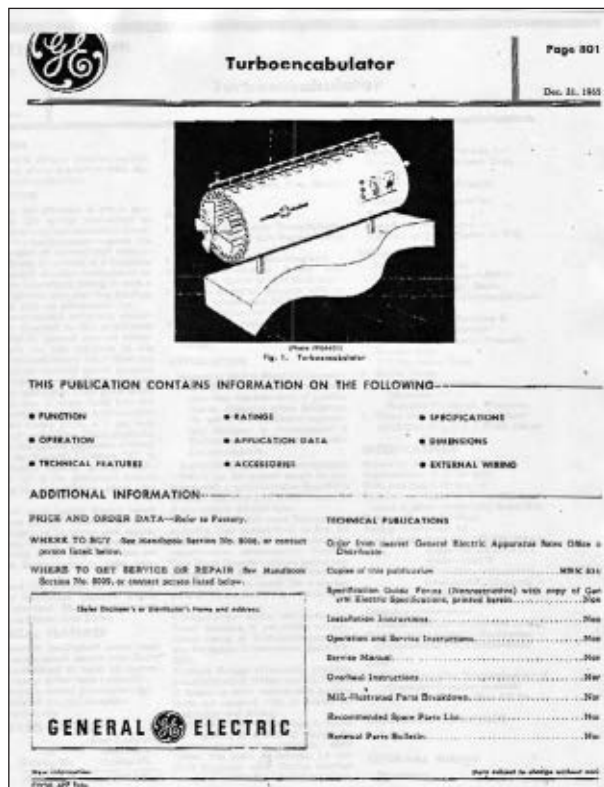
It seems that the Product

Development Team at Parallax has been quietly resurrecting the DigienCabulator. Originally created by General Electric in 1962 as the Turboencabulator (Figure 1), a form of the device is known to have been adopted for use by NASA as far back as the Gemini missions. New and improved versions (such as the Retroincabulator) are rumored to have played pivotal roles in the Mars Rover project, as well as the Hubble telescope. But unlike their expensive counterparts, the Parallax DigienCabulator

has been specifically adapted for hobby robotics use. For example, the original models used a difficult to implement version of the TCP/IP-OCP (RFC-1149) protocol (see the sidebar on A Short History Of TCP/IP-OCP) and were encumbered by old-fashioned current-loop I/O. The new DigienCabulator sidesteps this by incorporating a plethora of protocols and industry standard interfaces. The unit has 1-Wire, I²C, Bluetooth, and serial TTL I/O capabilities, as well as support for the less well known HTCP/1.0 (RFC-2324) protocol. They've even included an updated TCP/IP-OCP w/QOS (RFC-2549) to insure backwards compatibility. This makes communication incredibly flexible and compatible with just about every microcontroller and/or computer system on the market.

WHAT A DIFFERENCE A DAY AT MAKE MAKES!

A device like this doesn't just pop up on the market every day, so I'd like to provide a bit of background before we get into my hands-on review of DigienCabulator. At Maker Faire last year, I ran into Chris Savage, a product and support



■ FIGURE 1. Original reproduction of GE product catalog from December 31, 1962.

representative for Parallax. He was excitedly telling me about Parallax's efforts to create the DigienCabulator. Though I was skeptical, I told him that if they could build it, I would be glad to test it. Frankly, I felt they might be over-reaching as creating such a device would obviously be a monumental task. However, true to his word, Chris sent me an almost completely functional pre-release version of the device in March. I've been testing it in conjunction with the Boogiebot robot chassis (Figure 2) I detailed in the October '07 issue of *Nuts & Volts*. I decided to use this large bot as a test platform for a number of reasons, first of which was the power requirements.

Though it was pretty clear that the spec sheet was designed and intended for engineers, a quick read through followed by some head scratching (and admittedly a few Google searches!) showed that though the DigienCabulator device had a tolerance for a wide range of input voltages (from 3.3 μ V to 24V), it would draw a peak of just under 193.7 abamperes on startup. After this short in-rush period, the current draw would quickly drop to a much lower 37.633 abamperes during operation and 17.633 abamperes when quiescent. I asked Chris about these amazing specifications and he gave me a bit of insight on how they were accomplished in spite of the fact that the design relied on traditional components rather than MOSFETs. Seems they were able to solve the stability problem inherent in bipolar transistors by simply doping the substrate with lithium.

Even after my conversation with Chris, I didn't know if my BOEBOT would be able to support the current requirements so I decided to err on the side of caution. I chose the Boogiebot as a base for the DigienCabulator as it had an on-board 24V supply from dual lead-acid gel cell batteries. Now I just had to find a way to mount it on the Boogiebot chassis. This looked tough as the unit came with no

A SHORT HISTORY OF TCP/IP-OCP

Though the underlying transport media predates the space age, TCP/IP-OCP was formally submitted as RFC-1149 by David Waitzman at BBN Systems and Technologies Corporation, BBN Labs Division in 1990:

www.faqs.org/rfcs/rfc1149.html

RFC-1149 goes into great detail on how data can be transported by avian carriers for high delay, low throughput traffic. Though originally just a concept RFC with no supporting test data, this protocol was finally implemented in 2001 when Norway's Bergen Linux User Group joined forces with the Vesta Brevdueforening Group to do the first full-scale test of this previously theoretical idea. The test is detailed here:

<http://news.bbc.co.uk/1/hi/sci/tech/1321176.stm>

On April 28th, a simple "PING" command was sent between two computers a few kilometers apart in the suburbs of Bergen. Though there was some packet loss, a packet did arrive back at the starting point resulting in the CPIP network delivering a data transfer speed of 0.08 bits per second. Further tests of the CPIP got data rates as high as 0.15 bps.

Now that a proof of concept had shown the RFC-1149 was actually possible to implement, it was revisited and updated by David Waitzman and re-released in 1999 as RFC-2549:

www.faqs.org/rfcs/rfc2549.html

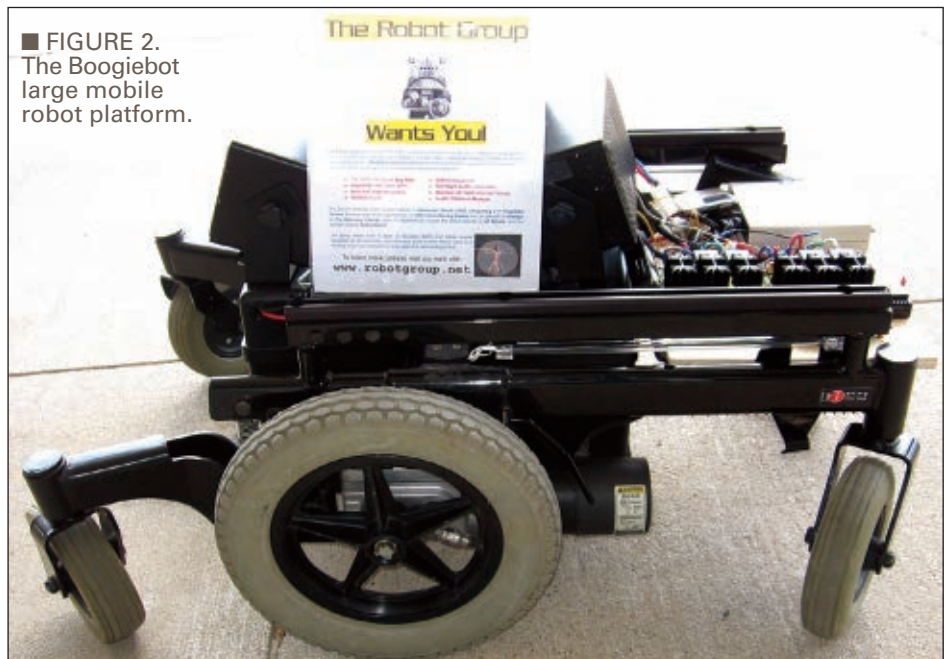
This new incarnation of the protocol incorporated QOS (Quality Of Service) specifications that could increase the throughput of the system.

mounting instructions (*Note: Chris assured me that production units would contain both mounting instructions and a bracket*) and the device itself had a rather strange geometry.

MEASURE ONCE, CUT TWICE!

Using the calipers I received recently as a present (thanks Rick!),

■ FIGURE 2.
The Boogiebot
large mobile
robot platform.





■ FIGURE 3. Available mounting point on the Boogiebot chassis.

I was able to carefully calculate the exact space the DigienCabulator would require. There was an empty area directly behind the audio preamplifier and quite conveniently located right by the power bus (Figure 3). I did a test fit by rotating the DigienCabulator until one of its six hydrocopic marzel vanes was in

parallel with the ambiphase bipolar shaft. Once aligned that way, it looked like a perfect fit! Now that I had a place for the unit, all I would need would be a mounting bracket to secure the unit to the chassis. I knew I was going to have to enlist my favorite machinist, Rick Abbott.

I got Rick on the phone and outlined the project. We discussed the mechanical aspects of getting the

WARNING ON THE USE OF DIHYDROGEN MONOXIDE (DHMO)!

Please note that the addition of DHMO to an unshielded robot can be dangerous or fatal to your robot, or even you! Proper care and handling should be taken into account if DHMO is used in, on, or around your electronic or robotic experiments. Some good information is maintained by the Dihydrogen Monoxide Research Division based in Newark, DE. They define DHMO as:

"A colorless and odorless chemical compound, also referred to by some as Dihydrogen Oxide, Hydrogen Hydroxide, Hydronium Hydroxide, or simply Hydric acid. Its basis is the highly reactive hydroxyl radical, a species shown to mutate DNA, denature proteins, disrupt cell membranes, and chemically alter critical neurotransmitters. The atomic components of DHMO are found in a number of caustic, explosive, and poisonous compounds such as Sulfuric Acid, Nitroglycerine and Ethyl Alcohol."

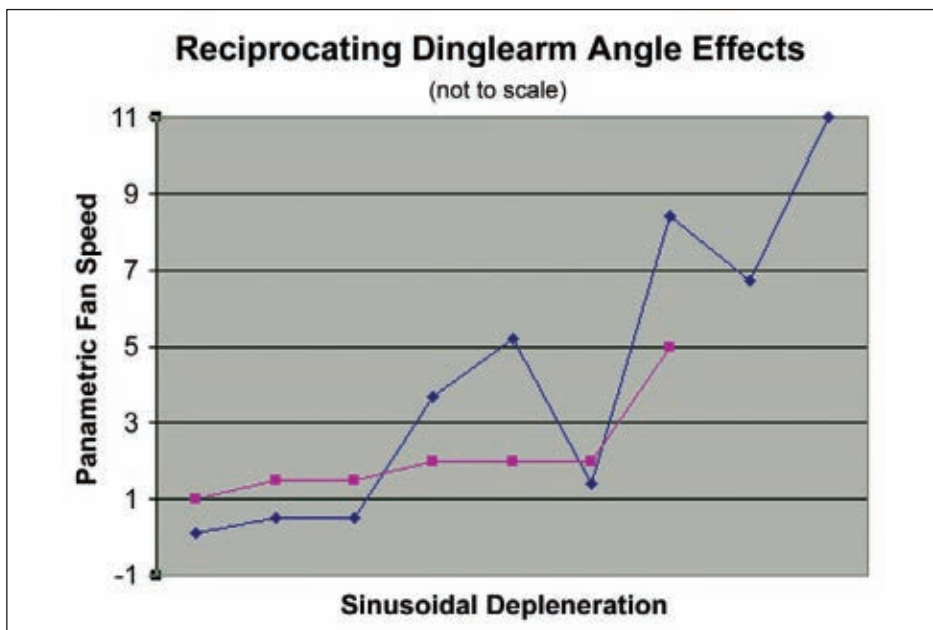
Obviously great care should be taken when dealing with this material. For MSDS information and handling precautions, please visit the DHMO website located at www.dhmo.org/facts.html.

Though there has been at least one attempt to outlaw DHMO, many feel that if used with care, it is safe for even hobbyists to use. But please, be alert and cautious when handling this controversial substance.

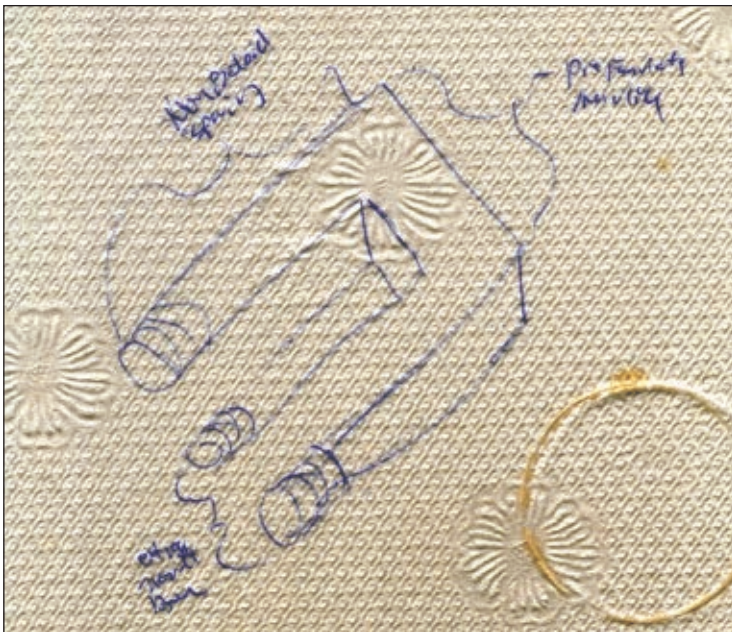
DigienCabulator mounted on the Boogiebot, but after Rick became a bit more familiar with the DigienCabulator and its properties (I emailed him the spec sheet), he said he was more concerned with how the device would operate when mounted. He suggested that I call Paul Atkinson another Robot Group member (and electrical engineer by trade) who might be able to help with the first (and most obvious) problem of the inverse reactive current generated when the unilateral phase detractors came very close to the existing sperving bearings.

"MY KINGDOM FOR A BOLOID STATOR!"

I went to lunch with Paul where after some discussion, he explained the problem in depth. Turns out that because of the way Parallax had encased the DigienCabulator, its main coil was wound in a normal lotazode deltoid configuration (as we both expected). However, it was placed in the panendemic semi-boloid slots of



■ FIGURE 4. Chart showing effects of panametric fan speed (phase-loop coupling is purple, anti-phase is blue).



■ FIGURE 5. Original napkin sketch of the mounting bracket.

the stator! This clearly meant that every seventh conductor would have to be connected by a non-reversible tremi pipe on the differential gurdal spring in order to be congruent with the symmetrical grammeters. Though not an optimal configuration, Paul pointed out that it did put the reciprocating dingle arm in a direct line with the panametric fan, but we still had to deal with the unwanted sinusoidal depletionation (Figure 4). This was getting tricky! Paul ended up sketching up a rough design on a napkin for a bracket that he felt would hold the unit properly (Figure 5).

I took the napkin sketch to John Richter, a friend and talented CAD operator, and the next day he emailed me a detailed layout of the desired mounting bracket configuration (Figure 6) that gave me all the specs that Rick would need to craft it. I forwarded the design to Rick and made arrangements to meet up at his shop to help build the bracket. We put on some gloves and started to dig around in the scrap pile. In a few minutes, we found a single 8" by 4" piece of prefamulated amulite that weighed 8.6 Kurics (about 21.5 lbs).

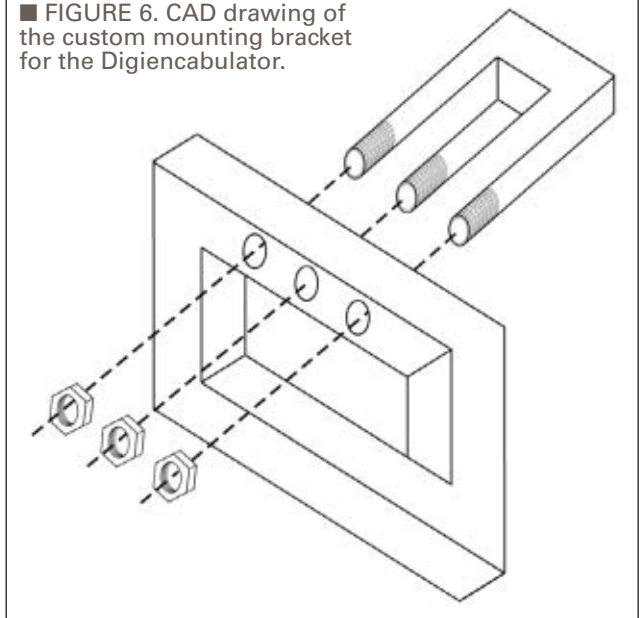
Though a bit heavy, we figured it would provide enough raw material to make the required pieces. Using this material, Rick was able to hand

craft the base plate using a malleable logarithmic casing of dihydrogen monoxide-coated Unobtanium (see the sidebar on Warning On the Use of Dihydrogen Monoxide). Like all Rick's work, this thing was not only a functional mechanical piece, but also a work of art. You see, not only did it allow for the inevitable fluorescent score motion, but the difficulty of arbitrating the backlash inherent in regurgitative purwell wennelsprockets (see the sidebar on Note On Wennelsprockets) was effectively eliminated! I've said it before, and I'll say it again: Rick's a genius!

THE LAST LAUGH

Now that I had the mounting taken care of, all I needed to do was wire it up. Again, I called on Paul to lend a hand. Since he was familiar with the spec sheet, he knew I was going to need some manestically spaced grouting brushes. It just so happened that he had some left from one of his other projects (lucky for me, Paul is a bit of a pack rat). He brought them over and we went to work, seating the brushes and then spending about an hour trying to get them to phase with the rotor slipstream. No joy. Paul sat and stared at the spec sheet for a bit and then discovered that as long as you don't reverse the polarity of the

■ FIGURE 6. CAD drawing of the custom mounting bracket for the DigienCabulator.



A NOTE ON WENNEL-SPROCKETS

For those that may not be aware, a wennel-sprocket is a lot like a Finnegan pin, except for where it attaches to the molly sprocket; it uses a plain bearing instead of a ball bearing. This reduces creatisfration to below 37 RMQs. Thanks to Carl Byrns for pointing this out!

DigienCabulator's primary feastock ring, the unit itself would supply the inverse duractant current for use in the unilateral phase detractors! Boy, did we feel dumb! For those of you who haven't had to deal with this

RESOURCES

■ Parallax
www.parallax.com

■ The original Turboencabulator
www.notepad.org/ge_turbo-enca-bulator.pdf

■ Unobtanium Manufacturing Source
www.unobtainium.com

■ Dihydrogen Monoxide Research Division
www.dhmo.org

■ The Robot Group
www.TheRobotGroup.org



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 Scottsdale, AZ 85261

Heavy Duty Gearhead Motor

Operates from 3VDC up to 30VDC. At 3VDC the unloaded current draw is .15Amp and the RPM is about 7. Size is 2.75"sq x .56"Thick. The motor is 2.5"L x 1.46"Dia. The output shaft of the gearhead is .37"Dia. "D" shaft about .8"L.

G16619 \$8.95 ea.

Super Micro Pager Motor

This tiny motor is only 0.16"Dia. x 0.45"L (excluding 0.10" long shaft with "D" weight attached). Motor can operate from 1V up to 5VDC. Resistance of motor is about 18Ω.

G16321 \$1.19 ea.

Audio Opto Coupler

Inside the black epoxy case is a 2 lead photocell (not a photodiode or photo-transistor) and a 2 lead LED. The LED requires about 10-16mA current and the resistance of the photocell varies from 150K up to megohms when the LED is off to under 400Ω when the LED is on.

G15396 \$0.99 ea.

12VDC Negative Ion Generator

This 2 1/4" x 1 5/8" x 7/8" module operates from 12VDC. Output is 15kV. Current draw at 12VDC is 50mA.

G9695 \$12.95 ea.

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This compact metal case flashlight features 8 powerful UV LEDs. Operates on 3 AAA batteries (included).

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*All orders must include Shipping Charges. Minimum order \$10.00 + Shipping

before, the only really new principle involved is that instead of power being frequency modulated by the relative motion of conductors and harmonic fluxes, it is pivoted by the medial interaction of magneto-reluctance and capacitive duractance! After we figured that out, it made perfect sense. In just a matter of minutes, we had a fully-functional DigienCabulator just like the guys at NASA!

LUCKY DUCK!

I know not everyone can have a DigienCabulator drop into their lap for testing and I know I've been darn lucky to get my hands on one of the first ones available. The sad part is that I know that I'll have to send the unit back eventually as it is only on loan. However, Chris at Parallax said they would send me a finished model as soon as it was market ready. In the meantime, I've had a great time playing with the DigienCabulator. Not even the lengthy calibration of the spiral decommutator (only required when the quasi-piestic valves got stuck) could dim my enthusiasm for this device. As soon as I have pricing and availability info, I'll note it in a future article. Thanks again to the good folks at Parallax for making this article possible! **NV**

Vern Graner can be contacted via email at vern@txis.com.

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LM630P3 - 3mw 630 nm 10.5 x 45 mm \$34.95

Red - Class IIb

LM650P10 - 10mw 650 nm 12 x 51 mm \$89.95

Laser Diode Visible Red - Class IIb

LD630-P10 - 10mw 635 nm 5 mm diode \$9.95

Green - Class IIIa 3 volt modules

LM532P5 - 5mw 532 nm 12 x 45 mm \$39.95

Infrared - Class IIb 3 volt modules

LM980P30 - 30mw 980 nm 12 x 30 mm \$49.95

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Includes circuit schematics on how to use.

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28K077 - 2kv 10ma 30 khz 7-9v 7x 1.25" \$9.95

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12 vdc with instructions on how to use.

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TRIG10 - 20 kv trigger/shock pulses \$54.95

SS0165 - +20kv 100ua \$29.95

SS0105 - Minus 20kv for neg ions \$24.95

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5 Channel Audio Mixer

- ✓ XLR mic input w/phantom
- ✓ Dual RCA unbalanced in's!
- ✓ Dual TRS line in's!
- ✓ RCA and TRS outputs!



The S-Mix is a compact 5-channel mixer packed with high-end features! Its design includes high quality, low noise op-amps for added headroom and cleaner signals. Features an XLR microphone input with phantom power, two RCA unbalanced inputs, and two 1/4" TRS line level inputs. Both 1/4" TRS and RCA outputs are provided for maximum versatility. Whether an XLR mic, CD player or other stereo line input, or a TRS instrument input, this mixer has it covered!

The S-Mix also comes in a rugged aluminum chassis with large rubber shock feet. When you have to put a gig together fast, there is no better solution! Runs on included 18V power adapter.

SASMIX 5 Channel Audio Mixer \$48.95

4 Channel Stereo Headphone Amp

- ✓ Four 1/4" stereo outputs!
- ✓ Individual level controls!
- ✓ Stereo 1/4" input
- ✓ Included 18V power supply



Once again, the Mini series has the solution to another common problem! One headphone or monitor jack, more than one person. Enough said!

The S-Amp delivers high quality headphone amplification to 4 separate headphone jacks, complete with independent gain controls for each output.

Providing high power levels and superb fidelity, the S-Amp is ruggedly built with large rubber bumper feet for shock protection. It also works great as a quick DA to give you 4 level controlled outputs from one source (like the satellite radio on my desk!) Includes 18V AC adapter. These are a gig bag must have!

SASAMP 4 Channel Headphone Amp \$48.95

Audio/Midi USB PC Interface

- ✓ Digital and analog I/O's
- ✓ Line and mic inputs!
- ✓ MIDI input and output
- ✓ USB2 high speed
- ✓ Up to 96kHz/24bit!



The ultra amazing tool for musicians and home studios, this PC interface allows you to record two tracks with zero latency from analog inputs! It features digital S/PDIF inputs and outputs, 2 analog inputs and outputs, MIDI input and output, and XLR mic inputs complete with phantom power! But that's only the start!

It also includes Steinberg's CuBase LE recording software. This powerful software gives you 48 tracks of recording at 96kHz, 64 MIDI tracks, and even cool functions like VST plug-ins and notation editing! It can also be used with virtually any other editing software. Just bring your laptop and you're all set!

US144 Tascam USB Audio Interface \$148.95

Professional USB to Digital Turntable

- ✓ Pro-quality high-torque direct drive turntable
- ✓ S-Shape tone arm for lower distortion and superior tracking
- ✓ Digital features like Key Lock (Master Tempo) and S/PDIF output
- ✓ 3 playback speeds (33, 45, 78 RPM), plus Quartz Lock and target light
- ✓ Pitch control slider with selectable range (±8%, 12%)
- ✓ Includes Stanton 500B cartridge, slip mat and cloth dust cover

Got shelves full of classic albums? Wondering what to do with all that vinyl? Even devoted vinyl enthusiasts know that the time has come! This Stanton digital kit solves all your problems, and there is no need to buy any additional software or interfaces! Features a USB output for a direct PC connection, RCA stereo line/instrument outputs and a digital S/PDIF digital coaxial output so it's ready for any setup you have! Included Cakewalk Pyro-5 software even helps you revive and restore those worn out LP's to a digital file that will last forever! Truly the professional turntable at a consumer price! Visit www.ramseyaudio.com for details.

T90USB Stanton USB Digital Turntable Package \$298.95



RCA-XLR Audio Bump Box

- ✓ Switchable instrument or speaker level inputs!
- ✓ Input level controls
- ✓ Dual outputs!



This bump-box is a great problem solver for interfacing and level matching between consumer and pro-level audio equipment! Murphy's Law, if you have a balanced XLR plug, it will need to go into an unbalanced RCA input... or vice versa. Always a problem until now!

This mini bump box quickly and easily converts RCA unbalanced (-10dBV) to XLR balanced (+4dBu) in either direction! Level controls for both are included to properly match the audio levels. The S-Convert is small enough to fit anywhere, but built tough in a rugged aluminum chassis with large rubber shock feet so survive portability and life on the road! Includes 18V AC power adapter.

SASCONV RCA/XLR Audio Bump Box \$48.95

Mini Stereo Audio Direct Box

- ✓ Instrument or spkr input!
- ✓ 48V phantom power!
- ✓ Switchable ground lift!
- ✓ 1/4" link output



This is the only direct box you will ever need! Quite simply it solves the problem of direct audio insertion from a non-standard audio source into a mixer or recorder. Now it's a breeze to directly connect any device from a guitar, bass, keyboard, signal processor, or even high powered speaker output to the microphone inputs of your device!

And it's not just a single channel DI, but it's stereo, just like having two boxes in one! This is great to feed consumer stereo audio decks, multi-channel keyboards or electronic drum sets, etc. to your PA system, mixer, PC, or PC audio interface. Everyone knows you can't connect speaker outs to a mic... until now, with this extremely handy direct box!

SASDIRPLUS Stereo Audio Direct Box \$38.95

8 Track Digital Production Studio

- ✓ CF or 40G HDD!
- ✓ CD burner!
- ✓ USB interface
- ✓ Multiple effects
- ✓ CD burner!



The brand new highly acclaimed little brother to the Tascam 2488MKII! This small yet powerful portastudio gives you professional 8 track mastering results at a price you can afford!

LCD displays give you visual feedback on levels, song positions, track editing, and a whole lot more. Multiple effects give you guitar, bass, vocal and drum programs as well as full control over reverb types and other effects. The built-in CD burner lets you mix your program down to a standard stereo 2-track master. You can also save your work on a CF card or a built-in 40G hard drive depending on the model. It truly doesn't get any easier than this!

DP02 Track Studio, 40G HDD \$498.95
DP02CF 8 Track Studio, 1G CF Card \$298.95

The Latest... And the Greatest!

Portable Digital Audio Recorder

- ✓ Records 90°, 120°, or 360° with 4 built-in mics!
- ✓ SD card storage!
- ✓ Records up to 96kHz 24 bit or MP3 to 320kbps
- ✓ Record up to 133 hours!
- ✓ Includes everything!



It's a simple idea: provide brilliant stereo recording in an easy-to-use, ultra-portable device. Now everyone can record pristine audio in an infinite variety of applications. From seminars and conferences, to electronic news gathering (ENG) and podcasting, to musical performances, songwriting sessions and rehearsals, the H2 provides amazing recording quality. And no matter what kind of music you perform or the instrument you play, the H2 can effortlessly record it in high-quality stereo.

The H2 is the only portable recorder with 4 mic capsules onboard for 360° recording. The W-X/Y configuration of the mics allows the audio to be decoded instantly, bringing these four signals together for unparalleled stereo imaging. But it doesn't stop there. You can record from the front of the H2 in a 90° pickup pattern or the rear of the H2 in a 120° pickup pattern at up to 96 kHz/24-bit resolution as a WAV file, or as an MP3 file at bitrates up to 320 kbps. Additionally, you can record in a 360° pickup pattern at up to 48kHz/24-bit resolution which will allow you to convert your recordings to 5.1 Surround! A 512MB SD card is included, but you can use up to a 4GB card to achieve a stunning 133 hours of typical MP3 audio!

Includes stereo earbuds, 1/8" to RCA audio cable, mic clip adapter, tripod stand, USB cable, AC power adapter, and a 512MB SD card. All you need to provide are two standard AA batteries if you need battery operation!

H2 Professional Digital Recorder \$198.95

Pro Pod-Casting/Recording Kit



- ✓ Professional USB studio condenser mic!
- ✓ No PC audio interface required!
- ✓ Cakewalk's Sonar LE workstation software!
- ✓ Everything you need in a custom foam fit aluminum travel case!

Samson changed the way the world professionally records audio with their USB studio condenser microphones. For the first time you can plug a studio mic directly into your USB port and eliminates the need for an expensive audio interface!

Now you can get everything you need for your home recording, studio recording, or podcasting to make you sound like one of the pro's!

Includes Samson's famous C01U USB studio condenser microphone, a pro shock mount, desk stand, cable, and Cakewalk's popular Sonar LE digital workstation software...all in a custom designed sturdy aluminum case! This makes it perfect for on-location music sessions, corporate events, interviews, presentations, voice overs, training CD's and a lot more. Be one of the first to make your work sound just like the commercial broadcasters, without spending a fortune on a home studio, PC audio interfaces, or additional workstation software!

SAC01UPK USB Studio Recording Kit \$168.95

Davis OBDII CarChip Pro

The incredible OBDII plug-in monitor that has everyone talking! Once plugged into your vehicle it monitors up to 300 hours of trip data, from speed, braking, acceleration, RPM and a whole lot more. Reads and resets your check engine light, and more!

8226 CarChip Pro OBDII Monitor \$99.95

**Practice Guitar Amp & DI**

Practice your guitar without driving your family or neighbors nuts! Works with any electric, acoustic-electric, or bass guitar. Plug your MP3 player into the aux input and practice to your favorite music! Drives standard headphones and also works as a great DI!

PGA1 Personal Practice Guitar Amp Kit \$64.95

**Passive Aircraft Monitor**

The hit of the decade! Our patented receiver hears the entire aircraft band without any tuning! Passive design has no LO, therefore can be used on board aircraft! Perfect for airshows, hears the active traffic as it happens! Available kit or factory assembled.

ABM1 Passive Aircraft Rcvr Kit \$89.95

**LED Blinky**

Our #1 Mini-Kit for 35 years! Alternately flashes two jumbo red LED's. Great for signs, name badges, model railroading, and more. Used throughout the world as the first learning kit for students young and old! Great solder practice kit. Runs on 3-15 VDC.

BL1 LED Blinky Kit \$7.95

**Laser Light Show**

Just like the big concerts, you can impress your friends with your own laser light show! Audio input modulates the laser display to your favorite music! Adjustable pattern & speed. Runs on 6-12VDC.

LLS1 Laser Light Show Kit \$44.95

**Electronic Siren**

Exactly duplicates the upward and downward wail of a police siren. Switch closure produces upward wail, releasing it makes it return downward. Produces a loud 5W output, and will drive any speaker! Horn speakers sound the best! Runs on 6-12VDC.

SM3 Electronic Siren Kit \$7.95

**Universal Timer**

Build a time delay, keep something on for a preset time, provide clock pulses or provide an audio tone, all using the versatile 555 timer chip! Comes with circuit theory and a lots of application ideas and schematics to help you learn the 555 timer. 5-15VDC.

UT5 Universal Timer Kit \$9.95

**Voice Activated Switch**

Voice activated (VOX) provides a switched output when it hears a sound. Great for a hands free PTT switch or to turn on a recorder or light! Directly switches relays or low voltage loads up to 100mA. Runs on 6-12 VDC.

VS1 Voice Switch Kit \$9.95

**Tone Encoder/Decoder**

Encodes OR decodes any tone 40 Hz to 5KHz! Add a small cap and it will go as low as 10 Hz! Tunable with a precision 20 turn pot. Great for sub-audible "CTS" tone squelch encoders or decoders. Drives any low voltage load up to 100mA. Runs on 5-12 VDC.

TD1 Encoder/Decoder Kit \$9.95

**RF Preamplifier**

The famous RF preamp that's been written up in the radio & electronics magazines! This super broadband preamp covers 100 KHz to 1000 MHz! Unconditionally stable gain is greater than 16dB while noise is less than 4dB! 50-75 ohm input. Runs on 12-15 VDC.

SA7 RF Preamp Kit \$19.95

**Touch Switch**

Touch on, touch off, or momentary touch hold, it's your choice with this little kit! Uses CMOS technology. Actually includes TWO totally separate touch circuits on the board! Drives any low voltage load up to 100mA. Runs on 6-12 VDC.

TS1 Touch Switch Kit \$9.95

**Walking Electronic Bug**

Built around a pair of subminiature cell phone motors, this bug wanders around looking for things to bump into! Sensors below his LED eyes sense proximity and make him turn away! Steer him with flashlights too! Runs on two "N" batteries.

WEB1 Walking Bug Kit \$29.95

**Mad Blaster Warble Alarm**

If you need to simply get attention, the "Mad Blaster" is the answer, producing a LOUD ear shattering raucous racket! Super for car and home alarms as well. Drives any speaker. Runs on 9-12VDC.

MB1 Mad Blaster Warble Alarm Kit \$9.95

**DTMF Encoder Decoder**

Decodes standard Touch Tones from telephones, radio, or any audio source. Detects and decodes any single digit and provides a closure to ground up to 20mA. Great for remote tone control. Runs on 5VDC.

TT7 DTMF Encode/Decode Kit \$24.95

**Super Snoop Amplifier**

Super sensitive amplifier that will pick up a pin drop at 15 feet! Full 2 watt output drives any speaker for a great sound. Makes a great "big ear" microphone to listen to the "wildlife" both in the field and in the city! Runs on 6-15 VDC.

BN9 Super Snoop Amp Kit \$9.95

**Water Sensor Alarm**

This little \$8 kit can really "bail you out"! Simply mount the alarm where you want to detect water level problems (sump pump!). When the water touches the contacts the alarm goes off! Sensor can even be remotely located. Runs on a standard 9V battery.

MK108 Water Sensor Alarm Kit \$7.95

**RF Actuated Relay**

Just what you need when adding a preamp or power amp in line with an antenna! Auto senses RF and closes an on-board DPDT relay that's good to UHF at 100W! Also great to protect expensive RF test equipment. Senses as low as 50mW!

RFS1 RF Actuated Relay Kit \$19.95

**HV Plasma Generator**

Generate 2" sparks to a handheld screwdriver! Light fluorescent tubes without wires! This plasma generator creates up to 25kV at 20kHz from a solid state circuit! Build plasma bulbs from regular bulbs and more! Runs on 16VAC or 5-24VDC.

PG13 HV Plasma Generator Kit \$64.95

**Air Blasting Ion Generator**

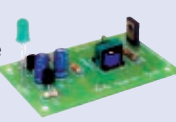
Generates negative ions along with a hefty blast of fresh air, all without any noise! The steady state DC voltage generates 7.5kV DC negative at 400uA, and that's LOTS of ions! Includes 7 wind tubes for max air! Runs on 12-15VDC.

IG7 Ion Generator Kit \$64.95

**Tickle-Stick Shocker**

The kit has a pulsing 80 volt tickle output and a mischievous blinking LED. And who can resist a blinking light and an unlabeled switch! Great fun for your desk, "Hey, I told you not to touch!" Runs on 3-6 VDC.

TS4 Tickle Stick Kit \$12.95

**Stereo Ear Super Amplifier**

Ultra high gain amp boosts audio 50 times and it does it in stereo with its dual directional stereo microphones! Just plug in your standard earphone or headset and point towards the source. Great stereo separation besides! Runs on 3 AAA batteries.

MK136 Stereo Ear Amplifier Kit \$9.95

**IC AM/FM Radio Lab**

Learn all about AM/FM radio theory, IC theory, and end up with a high quality radio! Extensive step-by-step instructions guide you through theory, parts descriptions, and the how's and why's of IC design. Runs on a standard 9V battery.

AMFM108K AM/FM IC Radio Lab Kit \$34.95

**SMT Multi-Color Blinky**

The ultimate blinky kit! The 8-pin micro-controller drives a very special RGB LED in 16 million color combinations! Uses PWM methods to generate any color with the micro, with switchable speed selection. SMT construction with extra parts when you lose them! 9V battery.

SBRGB1 SMT Multi-Color Blinky Kit \$29.95

**3-In-1 Multifunction Lab**

The handiest item for your bench! Includes a RoHS compliant temp controlled soldering station, digital multimeter, and a regulated lab power supply! All in one small unit for your bench! It can't be beat!

LAB1U 3-In1 Multifunction Solder Lab \$129.95



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Q&A

WHAT'S UP:

Join us as we delve into the basics of electronics as applied to every day problems, like:

- ✓ Eight-bit Binary Counter
- ✓ Low Battery Cut-Off Circuit
- ✓ Single Phase Power Supply

■ WITH RUSSELL KINCAID

In this column, I answer questions about all aspects of electronics, including computer hardware, software, circuits, electronic theory, troubleshooting, and anything else of interest to the hobbyist. Feel free to participate with your questions, comments, or suggestions.

Send all questions and comments to:

Q&A@nutsvolts.com

BIRD FEEDING MONITOR

Q Being retired and in not the best of health with a limited income, could you suggest a circuit that would monitor bird feeders from a remote location?

When it's winter here, it is hard to access the feeders so I wait until they are empty and truly need refilling. Is there a circuit that when activated would send a signal to a master station in the house and light one of four LEDs (or a seven-segment display) to show which feeder is

empty? The furthest feeder is approximately 150 feet from the house. I have a somewhat limited knowledge of electronics, being an old tube jockey from the '50s.

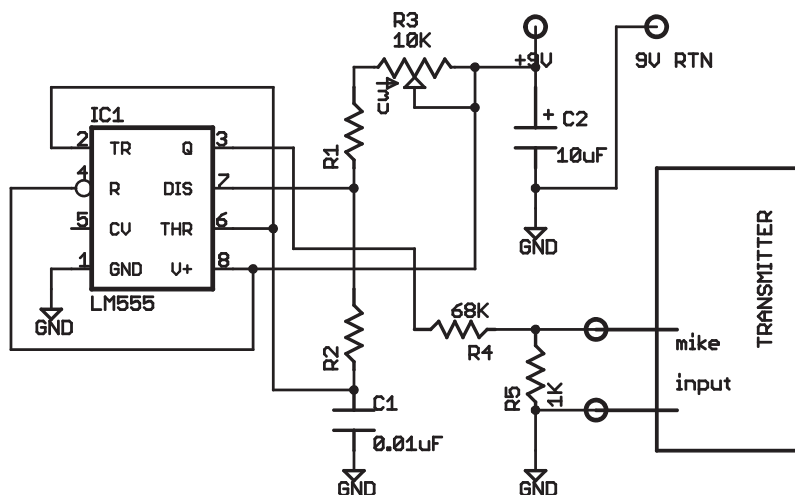
I can fabricate the mechanism necessary to monitor the weight problem, but not the rest needed to indicate the status of the feeders.

— Robert Brede

A The system that I have put together for you uses an FM transmitter kit from Jameco (www.jameco.com). The parts list is all Jameco part numbers so you don't have to deal with multiple sources, but you may have many of the parts on hand.

There will be a transmitter and modulator at each feeding station. The feeder empty switch will apply power to the circuits which will send a signal to an FM receiver in the house. I recommend using an analog FM receiver because it will have AFC and be able to track the drifting transmitter. The newer digitally tuned receivers rely on the rock solid frequency of the station and won't track a drifting transmitter.

The transmitter modulator is a 555 oscillator with a voltage divider to bring the output down to 100 millivolts. The transmitter audio input has a sensitivity of five millivolts and has a pot to set the level. A different modulation frequency is used for each feeder, separated enough so



PART	JAMECO PART NO.	PRICE
IC1 LM555	126797	\$0.66
TRANSMITTER	117604	\$12.90
R3 3/8 TRIMPOT	1156955	\$1.65
R4 1/4 WATT 68K	696307	\$0.01*
R5 1/4 WATT 1K	690865	\$0.01*
C1 NPO CERAMIC 0.01uF	768124	\$0.89
C2 10uF TANTALUM	33488	\$0.32
R1 1/4 WATT 43K	1KHZ VALUES	
R2 1/4 WATT 47K	691251	\$0.01*
	691260	\$0.01*
R1 1/4 WATT 33K	1.3KHZ VALUES	
R2 1/4 WATT 36K	691227	\$0.01*
	691235	\$0.01*
R1 1/4 WATT 27K	1.6KHZ VALUES	
R2 1/4 WATT 30K	691201	\$0.01*
	691219	\$0.01*
R1 1/4 WATT 15K	2.5KHZ VALUES	
R2 1/4 WATT 20K	691147	\$0.01*
	691171	\$0.01*

* MINIMUM ORDER OF 100

■ FIGURE 1

that the PLL in the receiving end can detect each one even if several are transmitting.

The LM567 is specified to work with a signal-to-noise ratio of -6 dB, but if all four transmitters are on, the signal-to-noise will be -12 dB and it might not work. On the other hand, it is not likely that all four feeders will be empty without you knowing it. You could use four receivers and tune each transmitter to a different frequency but that is more expense than necessary even though you can buy an FM radio (with clock) for less than \$10.

The transmitter kit comes with instructions, so I have just designed the modulator which is in Figure 1. There is a trimpot so you can tune the modulation frequency to the center of the PLL tone decoder in the receiver. The parts list for the different modulation frequencies is in the figure. Figure 2 is a possible layout; you don't need a printed circuit board, you can build the circuit on perf board instead.

If the receiver has an earphone jack, you can plug into that or replace the speaker with a 10 ohm resistor and send that signal to the LM567 tone decoder circuit. The schematic and parts list is in Figure 3; Figure 4 is a layout. The PLL is designed for an 8% bandwidth and since the R2-C2 components are 5%, the frequency could be off by 10%.

That would be a problem, so I recommend that you measure R2 and select one close to the value or buy 1% resistors. Jameco does not offer 1% resistors but Mouser (www.mouser.com) is a good source. The values of C3 and C4 are not critical. If you have capacitors on hand that are close, keep these facts in mind:

- C3 is the output filter; larger values give better noise immunity.

- C4 is the loop filter; smaller values give wider bandwidth but less noise immunity.

SINGLE PHASE POWER SUPPLY

Q I have been asked to buy or build a single phase power supply with these specifications:

- Input: 230 VAC, 50 Hz.
- Output frequency adjustable from 40 Hz to 60 Hz.
- Output voltage adjustable from 0 to 500 VAC.
- Output current is low; 0.5A to 2A would be acceptable.
- Some means of overvoltage/undervoltage protection is required.
- Digital readout of voltage and frequency is required.

Could you please help me to build a project like this?

Most equipment is very expensive (3500 Euros). If you think it would be better to buy one, please show me an available instrument.

— Theodore Karatzas

A It does not pay to design something that is already available and the Absopulse VFC501 500VA AC power source is close to

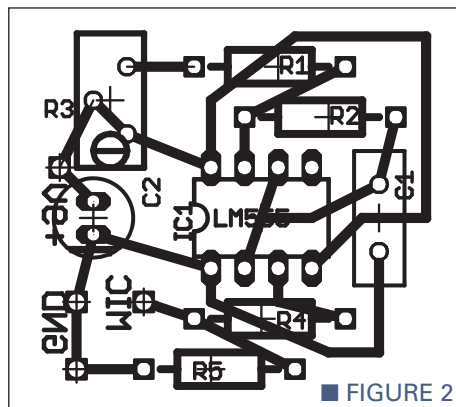
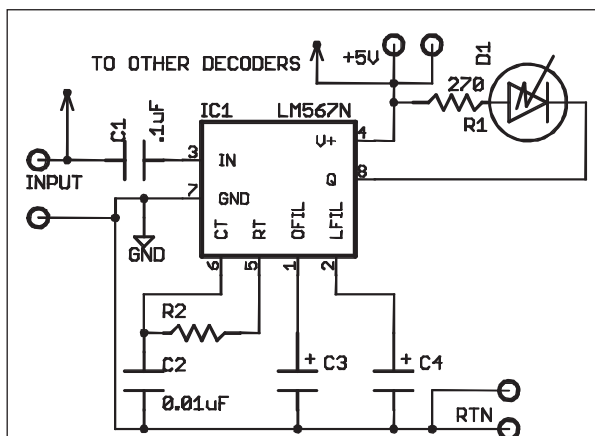


FIGURE 2

what you want. Its specs are:

- Input: 230 VAC, 50-420 Hz.
- Output frequency adjustable from 47 Hz to 424 Hz.
- Output voltage adjustable from 0 to 230 VAC.
- Output power 500VA, two amps max.



PART	JAMECO PART NO.	COST
IC1 LM567CN	24395	\$0.45
R1 270 OHM 1/4W	690726	\$0.01**
C1 0.1uF, 50V	849522	\$0.131*
C2 0.01uF NPO	768124	\$0.89
R2 91K 1/4W	691331	\$0.01**
C3 6.8uF, TANTALUM	545941	\$0.52
C4 3.3uF, TANTALUM	545941	\$0.34
D1 RED T-1 3/4	790081	\$0.07*
R2 68K 1/4W	691307	\$0.01**
C3 6.8uF, TANTALUM	545941	\$0.52
C4 3.3uF, TANTALUM	545941	\$0.34
D1 GRN T-1 3/4	790090	\$0.071*
R2 56K 1/4W	691286	\$0.01**
C3 3.3uF, TANTALUM	545941	\$0.34
C4 2.2uF, TANTALUM	545801	\$0.25
D1 YEL T-1 3/4	333622	\$0.34
R2 36K 1/4W	691235	\$0.01**
C3 3.3uF, TANTALUM	545941	\$0.34
C4 2.2uF, TANTALUM	545801	\$0.25
D1 BLU T-1 3/4	138691	\$1.75

NOTE: * = MINIMUM ORDER OF 10
** = MINIMUM ORDER OF 100

FIGURE 3

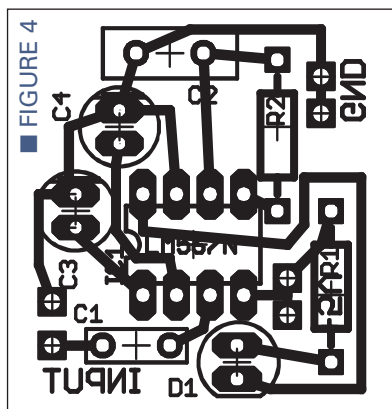


FIGURE 4

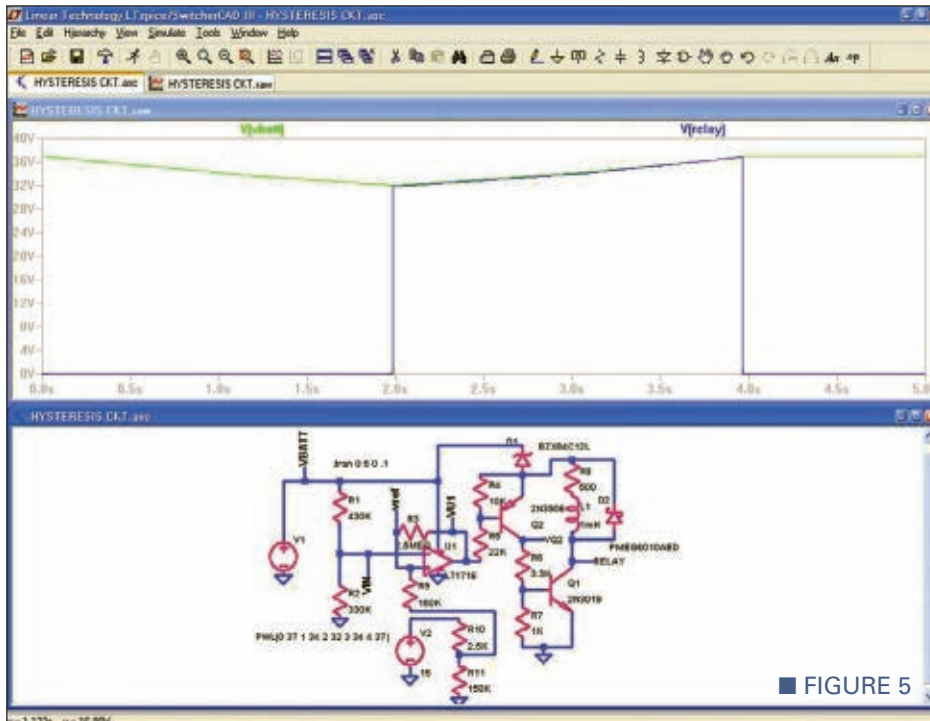


FIGURE 5

LOW BATTERY CUT-OFF CIRCUIT

I need a low battery disconnect circuit for a 36 volt (three each, 12 volts deep cycle batteries in series) emergency lighting system. The relay circuit would disconnect the 20 amp lighting load at about 32 volts and reconnect automatically when the charger comes back on and brings the voltage up to about 37 volts.

— John Rogus

This application calls for a hysteresis circuit. I tried to calculate the resistor values but finally just tweaked it in using LTSpice III (see Figure 5). I gave the problem to my grandson, Matthew, who derived the solution in Figure 6. When the V(batt) is high, the relay is open. You can see that the switching takes place near the low and high points of battery voltage. I used the devices that were available in the library so they are not necessarily ones that I would choose. The LT1716 is a nice comparator, low power, and operates up to 44 volts DC but it is in a SOT23 five lead surface-mount package so I used the LM293A in a dual eight pin through hole package. In Figure 7, the feedback through R7 pulls the

reference voltage at the positive input above the input when it switches so it is latched in that condition until the input rises above the reference causing it to switch again. The pot (R2) should be set near 14.75 volts or such that the switching is symmetrical with respect to 32 and 37 volts. The relay that I chose is from Magnecraft, Mouser part number 528-781XAXM4L-24D, rated 20 amps at 28 volts DC. You may be able to find a better one; a 48 volt contact rating would be better.

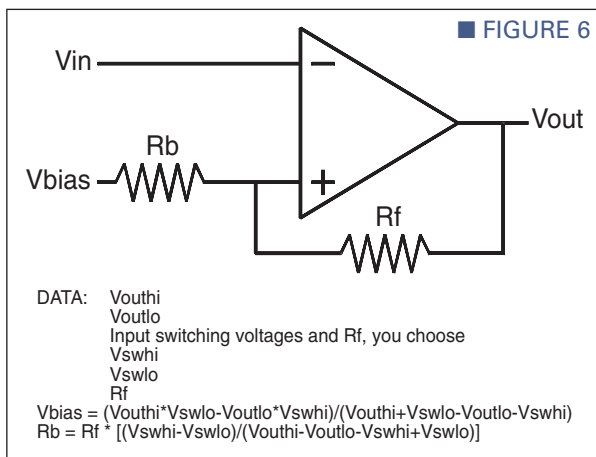


FIGURE 6

- Overload and short circuit protected.
- Digital readout of voltage and frequency.

The quoted price is \$1,984.50 US (1383 Euros) and you only need a 1:2 transformer to get 500 VAC output.

Good luck with your project.

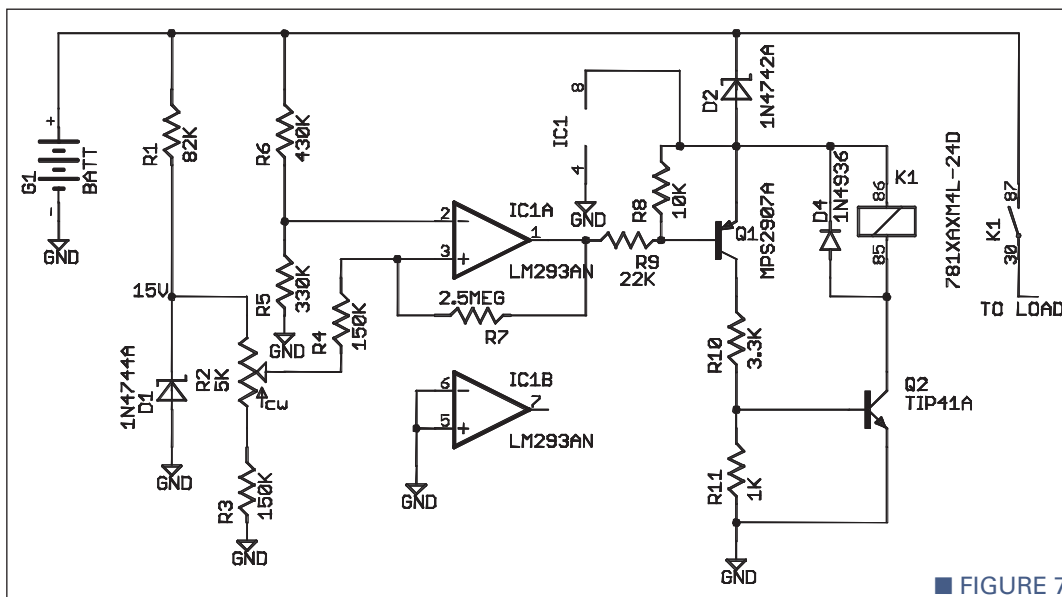


FIGURE 7

EIGHT BIT BINARY COUNTER

Q I'm writing to ask your recommendation for a suitable eight bit binary up-down counter. The output of the counter will feed the inputs of a DAC to produce a saw tooth wave. The output of the DAC will feed a voltage controlled resistor. I need to be able to set the counter to start at binary 50 and end at binary 200 instead of binary zero and 255, respectively, because the voltage controlled resistor is not entirely linear at the binary high and low number values. The counter also needs to have a reset pin to start it at the pre-defined lower value.

— Al Lovecky

A Figure 8 does what you want. The 74F269 is a power hog but it

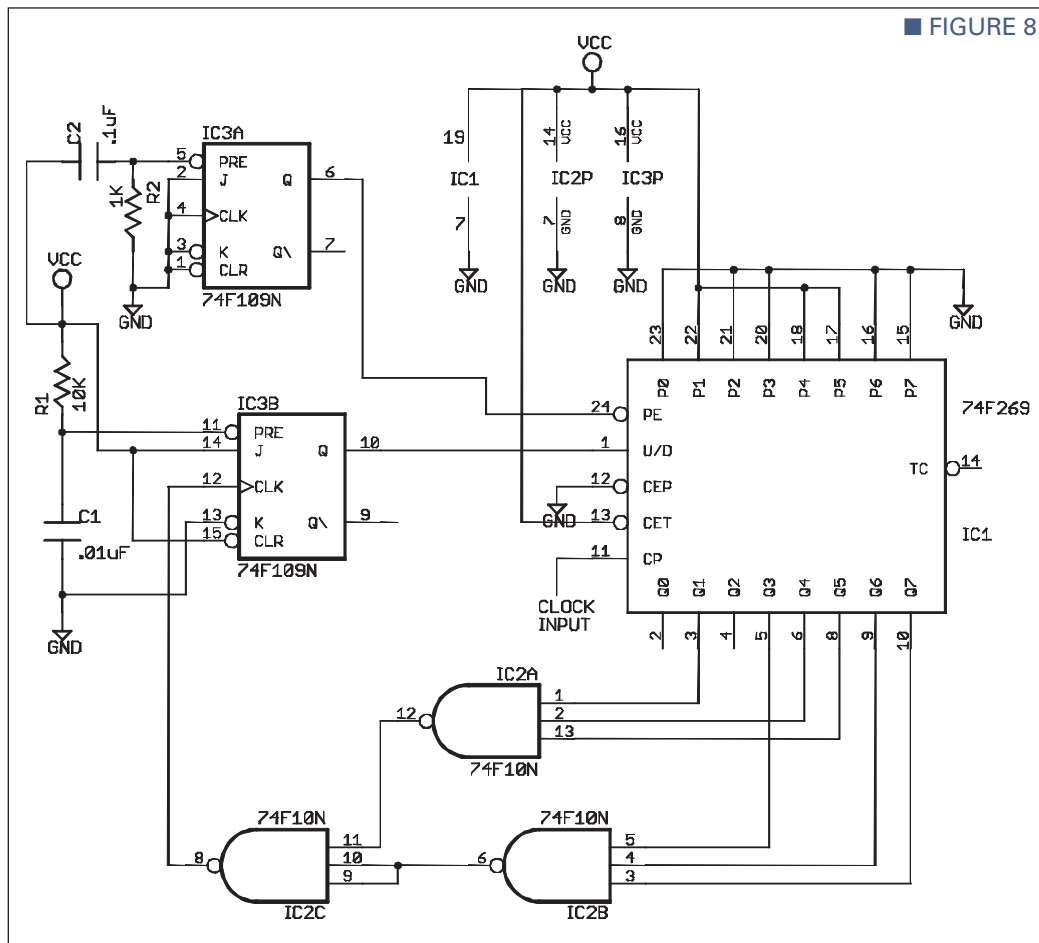


FIGURE 8

MAILBAG

Dear Russell,

In your January '08 Q&A column, you offered an excellent discussion on power transformer secondary current waveforms. Unfortunately, you didn't mention the most important bit of wisdom that should be passed along: the increase in secondary current rating relative to final DC output current. I wrote to TJ Byers about this issue as well, but I think the information came at a bad time.

Transformer secondary current is greater than DC output current. An example given by Frost (www.atc-frost.com/products/design/va.htm), for instance, points out that a 5 VDC 2A power supply using a full-wave bridge rectifier and capacitor input filter actually yields 3.6A secondary AC current and requires a transformer VA rating almost double its DC output wattage. The situation gets worse if you need more voltage for regulator headroom. This simple fact has led to the demise of many power supplies built by amateurs.

**Mike Hardwick,
for Decade Engineering**

Response: This result comes about because RMS requires squaring the pulse amplitude which makes it greater than the average (root mean square).

Dear Russell,

The Mailbox Timer from the January '08 Q&A column could also be solved with a capacitor connected to the battery when the door is closed and switched to the transmitter when the door is open. A single pole double throw switch will do it. The capacitor needs to be large enough to run the transmitter two or three seconds.

Lowell Wilson

Response: Yes, that will work but you need to know the transmitter current drain. If the transmitter current was 10 ma, the allowable voltage drop is one volt and the time is two seconds, then the capacitance should be: $C = I \cdot dT/dE = .01 \cdot 2 / 1 = .02$ farad. Mouser has a 0.1 farad, 5.5 volt supercap that would work; part number 878-FS0H1042ZF. Connect two in series to be safe.

Dear Russell,

I am a ham radio op, using preamps for two-way repeaters in

VHF/UHF communications. There is a kit available right in the February issue from Ramsey in their ad on page 21; RF Preamp Kit #SA7 for \$19.95. This needs to be assembled, however, and needs a power supply, as well.

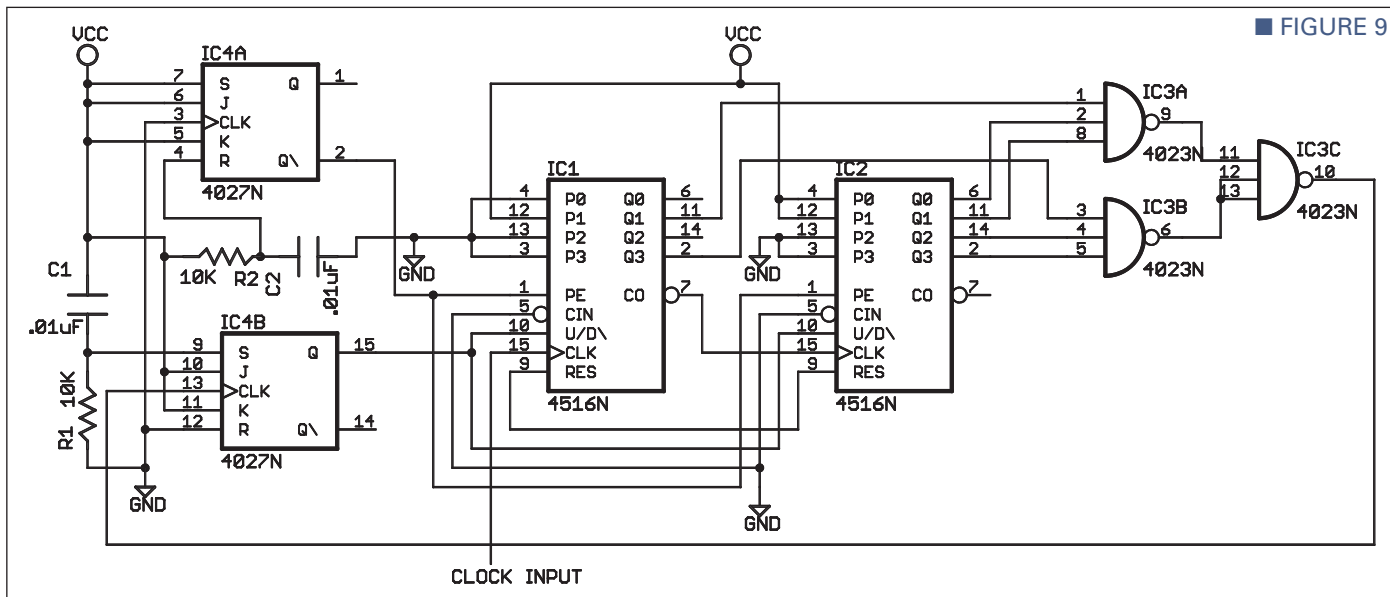
There is another company called MCM which has available SATV/CATV preamps made exactly for what Nathaniel needs in his question. Their website is www.mcminone.com. On page 282 of their 2007 catalog, they have listed a ZVM-201 RF broadband distribution amp for \$21.50; frequency range 50-550 MHz, gain 20db, noise figure 3.5 db.

This amplifier has its own internal power supply and runs from 110V, AC power and is housed in a metal box. The connectors are type F6 which is the type used in cable systems.

The part number for ordering from MCM is 33-2845.

Dan Harger, W8BCI

Response: Thanks for the feedback, Dan; this is certainly much better than my one transistor amp. However, if Nathaniel uses the Terk TV55 antenna, I don't think a preamp will be needed.



■ FIGURE 9

is the only eight bit up/down counter that I found. It is good to 100 MHz, if that is important to you. You might choose different gates, depending on your speed requirements.

The binary number 50 is 110010. That number is tied to the parallel input of the eight bit counter to make it start at 50, and is decoded at the output to switch from counting down to counting up. The binary number 200 is 11001000. That number is decoded at the output to switch from counting up to counting down.

I used the fact that a NAND gate

is also an inverted NOR in IC2C to clock the flip-flop and toggle the counter up/down pin. The RC network, R1 and C1, puts a temporary ground on the preset input of IC3B so that the counter starts counting up. The RC network, R2 and C2, puts a temporary high on the preset of IC3A so the ground on CLR is active, setting Q low temporarily which loads binary 50 as the start count.

Figure 9 is the same circuit using the 4000 series CMOS which can operate with VCC up to 15 volts DC. The power is much less but so is the

speed. I estimate 2 MHz max at 5 volts; 5 MHz at 15 volts.

For a manual reset, just connect a two pole momentary pushbutton switch across C1 and C2.

USB TO PARALLEL ADAPTER

At long last, I just bought a new computer with an Intel Core2 Quad CPU, and when I got it home, I found that there was no parallel port to connect to my three printers (through my A-B-C switch box). Is there some way that doesn't break the bank that I can connect my printers through the USB ports on my new computer?

— Paul Tilson

You should become familiar with Google (www.google.com) — that is what I used for this answer.

Sewelldirect.com has a USB to Centronics parallel adapter (part no. SW-1302) for \$13.95. You can hardly buy the cable alone for less. It is not compatible with all-in-one printers or scanners.

Cablestogo.com has a USB to IEEE1284 adapter, part no 15898, for \$24.99. This part has bidirectional communication capability. IEEE1284 also supports Centronics parallel in Compatibility mode. **NV**

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Meet Leah Buechley, developer of LilyPad — a sew-able microcontroller — and fellow geek. Leah used SparkFun products and services while she developed her LilyPad prototype.

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NEW PRODUCTS

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C WHAT HAPPENS

C*What Happens*, by David Benson, is a series of explanations and examples for those who want to learn to program PIC® microcontrollers using the C programming language. It is assumed that the reader has no knowledge of PIC microcontrollers or programming, but does have a rudimentary understanding of electronics.

The reader will learn to create programs by making selections from a large variety of built-in functions provided in the CCS C compiler, writing his/her own functions as needed, and writing executable statements. The reader will 'C what happens' by programming a PIC with the newly created code and exercising it using a simple circuit described in the book.

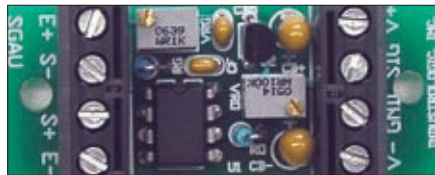
The subject matter is laid out in a logical progression from simple to not-so-simple and is illustrated with lots of examples. The table of contents is available on the publisher's website.



For more information, contact:
Square 1 Electronics
 PO Box 1414
 Hayden, ID 83835
 Tel: 208-664-4115
 Web: www.sq-1.com

UNIVERSAL STRAIN GAUGE AMPLIFIER BOARD

Industrologic, Inc., has released their SGAU, Universal Strain Gauge



Amplifier board. The SGAU is a small printed circuit board assembly designed to amplify strain gauges arranged in a full Wheatstone bridge configuration, and is suitable for many applications where a bridge or differential input amplifier is required.

The SGAU is based on the Analog Devices AMP04 precision instrumentation amplifier, and may be operated with a single or dual power supply to provide single-ended or bipolar output.

In addition to its gain and offset adjustment trimmer pots, the SGAU includes an on-board, five volt regulator to provide an excitation voltage for strain gauge bridges. Screw terminal block connections and mounting holes round out the SGAU's list of features, providing an easy-to-use instrumentation amplifier for many applications.

For more information, contact:
Industrologic, Inc.

3201 Highgate
 St. Charles, MO 63301
 Tel: 636-723-4000
 or 800-435-1975
 Web: www.industrologic.com

KICKAMP

NetMedia®, Inc., has launched its kickAMP™ product line with the new kickAMP-40, a miniature digital Class-D 40 watt stereo audio amplifier that enables



computers, game systems, musical instruments, and portable media players (iPods, MP3/CD/DVD players) to drive audio through conventional floor, wall, bookshelf, or ceiling speakers. Designed for consumers on the go, kickAMP-40 is perfect for homes, hotels, dormitories, churches, barracks, or anywhere its small size and big sound will enhance work or play. The kickAMP-40 uses state-of-the-art digital amplifier technology to deliver audiophile performance at a consumer price. It outputs 40 watts (2 X 20W at 8 ohms) of power with low distortion (0.11% THD+N at 50% power) and a high signal to noise ratio (greater than 99dB). Its rugged aluminum case is very small and lightweight: 2.2" wide, 2.7" deep, 0.95" tall; 5.6 ounces.

This amplifier provides excellent power in a tiny package, yet it runs cool, green, and quiet without need of a fan at 92% efficiency.

For more kickAMP information contact NetMedia, Inc., or visit the kickAMP website listed below.

For more information, contact:
NetMedia, Inc.
 Web: www.netmedia.com
 or www.kickAMP.com

PICOSCOPE 2000 SERIES SCOPES

Each new model in the PicoScope 2000 series is an oscilloscope, spectrum analyzer, signal generator, and arbitrary waveform generator (AWG) all in one unit, making it versatile and economical. With bandwidths up to 25 MHz and sampling rates up to 200 MS/s, the new scopes have a compact footprint of 100 mm x 135 mm (3.93



in x 5.31 in), making them small enough to fit easily into a laptop or travel bag.

The new PicoScope 2000 series scopes have two BNC input channels, a third BNC for a signal generator and arbitrary waveform generator output, and a USB port. Power is taken directly from the PC, and the scopes use the full USB 2.0 bandwidth of 480 Mbps to achieve rapid display updates without compromising accuracy and detail.

All PicoScope PC Oscilloscopes are supported by the same fully functional version of PicoScope 6 for Windows, which makes the most of the PC's processing power, storage, graphics, and communications. The familiar Windows interface and controls make the software easy to learn and operate, and convenient for everyday use. PicoScope owners can download software updates, feature extensions, and improvements that will remain free of charge for the lifetime of the product. They can also contact Pico's technical specialists for support by web, email, phone, or Skype, at no extra charge.

PicoScope 6 can save data in a range of formats including CSV text, PNG and BMP images, and MATLAB binary files. Drivers and examples are included for LabVIEW, C, C++, Delphi, and Visual Basic for integration into custom applications.

For more information, contact:
Pico Technology
Web: www.picotech.com

SMOOTH YOUR SOUND

Smooth Your Sound from Stackley Devices is a passive stereo



equalizer device that is used between headphones or earbuds and a sound source. It takes the edge off digitally remastered music and makes listening to speech or audible books less fatiguing. Smooth Your Sound shapes the audio passed through it to better fit the frequency response of the human ear. It also has applications for communication receiver listening and will clean up the audio sent from a PC sound card output into a set of powered speakers.

There is an adjustable model that works for both communications audio and home stereo systems.

For more information, contact:
Stackley Devices
Web:
www.stackleydevices.com

RESTORATION PREAMP™

This preamplifier from TDL Technology is designed for listening to and restoring mono recordings. It features a full range of Turnover frequencies and Rolloff attenuations easily selected by front panel rotary switches. It also has five switch-selectable Rumble Filter frequencies and 11 selectable output Lowpass Filter frequencies. It has

very low output noise and very low power line hum pickup — two features essential to creating a CD-quality wave file. The built-in low-noise power supply is as quiet as battery operation. Some of the features include:

- **INPUT:** Stereo: 47,000 ohms for both the left and right channels.
- **EXTERNAL PROCESSOR:** On the rear panel, there are out and in stereo connectors for using an external noise-reducing processor such as an Esoteric sound noise reducer, Packburn audio noise suppressor, CEDAR Retouch, or Diamond Cut Live. There is a front panel switch to enable or disable these connectors. Output impedance: 100 ohms; input impedance: 10K ohms.
- **GAIN:** Zero to 52, 56 or 60 dB at 30 to 35 Hz using the single-turn audio taper volume control. (The maximum gain is set with two internal, easily changed jumpers.)
- **MODE SWITCH:** This five position switch selects either the left channel, right channel, left + right (mono mode), left - right (vertical cut mode), or a left/right blend. Blend is a single-turn, continuous control that is fully left channel in its CCW position and fully right channel in its CW position. The middle position is equal parts Left and Right.

For more information, contact:
TDL Technology, Inc.
5260 Cochise Trail
Las Cruces, NM 88012-9736
Tel: **575-382-3173**
Fax: **575-382-8810**
Email: info@tdl-tech.com
Web: www.tdl-tech.com



HIGH VOLTAGE

POWER SUPPLY UNIT

BY PETER STONARD

It's fun to collect and experiment with forgotten technology! But, you'll need a stable high voltage power supply to get started.

Before solid-state electronics, vacuum tubes were used for everything — from high volume consumer radios and televisions to exotic one-of-a kind military and scientific applications. A lot of the old and interesting glass is still around to be found at hamfests, estate sales, and online auction sites.



I needed a couple of hundred volts to operate some Nixie tubes (see the sidebar to find out why), so I created a circuit. The prototype was so handy that I reworked it into a self-contained high voltage power supply unit (HVPSU) that I'm presenting here (Figure 1).

The HVPSU can be built into other projects as a module with a 0.1 inch grid and 0.1 inch pitch header, and can be connected with a wiring harness or mounted directly on perfboard for those projects not ready for a PCB (printed circuit board) commitment. The DC power

jack mates with a wall-wart brick, and an LED power on and neon high voltage active indicators complete the design. Table 1 is the target specification and Table 2 shows the performance measured.

Circuit Description

Look at Figure 2. To better understand the operation of the flyback circuit, see the sidebar on Flyback Theory of Operation and also Figures A and B.

The low voltage section provides a 5V DC output from a linear regulator, IC1. LED, D1 is a power on indicator fed from the 5V supply via R2. IC1 — a TO-220 type — does not require a heatsink for power dissipation of one watt or less. With a 12V DC, input we are limited to 140 mA, and the spec was arbitrarily set for 100 mA max (IC1 dissipates about 700 mW).

The project uses a mix of through-hole (TH) power components and SMT to conserve PCB space, but I

SAFETY WARNING!

Anyone attempting to construct and use this module should be aware of high voltage safety. Although the energy is limited, there are high voltages on the PCB, components, and connectors. Capacitors may store some energy after the power is removed. Remember, high voltage circuits bite fools!

Physical Size:

Double sided PCB 63 mm (2.5") x 51 mm (2.0") x 23 mm (0.88")

Input:

12V DC nominal (10V to 15V).

Outputs:

HV1: Regulated 175V to 200V DC, 0 to 15 mA.

HV2: Unregulated (zener clamped) 60V DC nominal, 0 to 5 mA.

LV1: Pass through of DC input voltage (aids in wiring or piggy-back assembly).

LV2: Regulated 5.0V \pm 5% DC, 0 to 100 mA.

Control Input: (optional)

TTL (0-5V) compatible HV shutdown: Used to turn off HV and save tubes, while keeping 5V and the DC pass through active. Defaults to HV on, connect to 5-15V to shut down.

Indicators:

DC Input: LED (Yellow).

HV Output: NE2 Neon.

Adjustments:

HV Set single turn potentiometer. Covers approx. 175-200V.

Mounting:

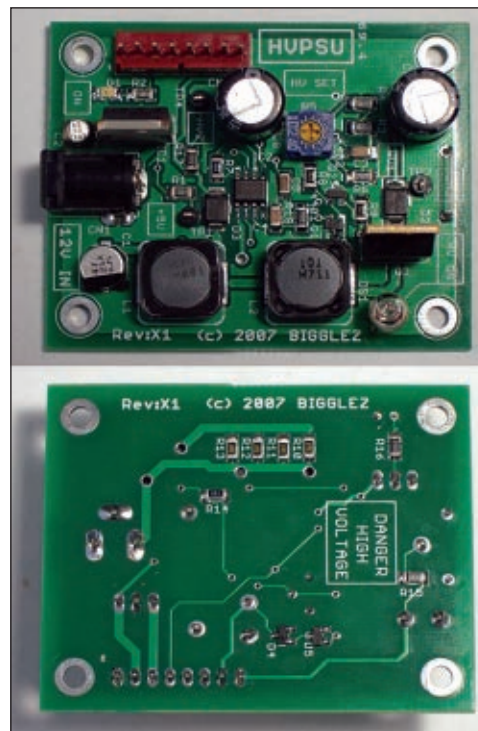
Four 3.3 mm (0.130") #4 clearance) mounting holes.

Connector: Molex KK-100 header eight-position header.

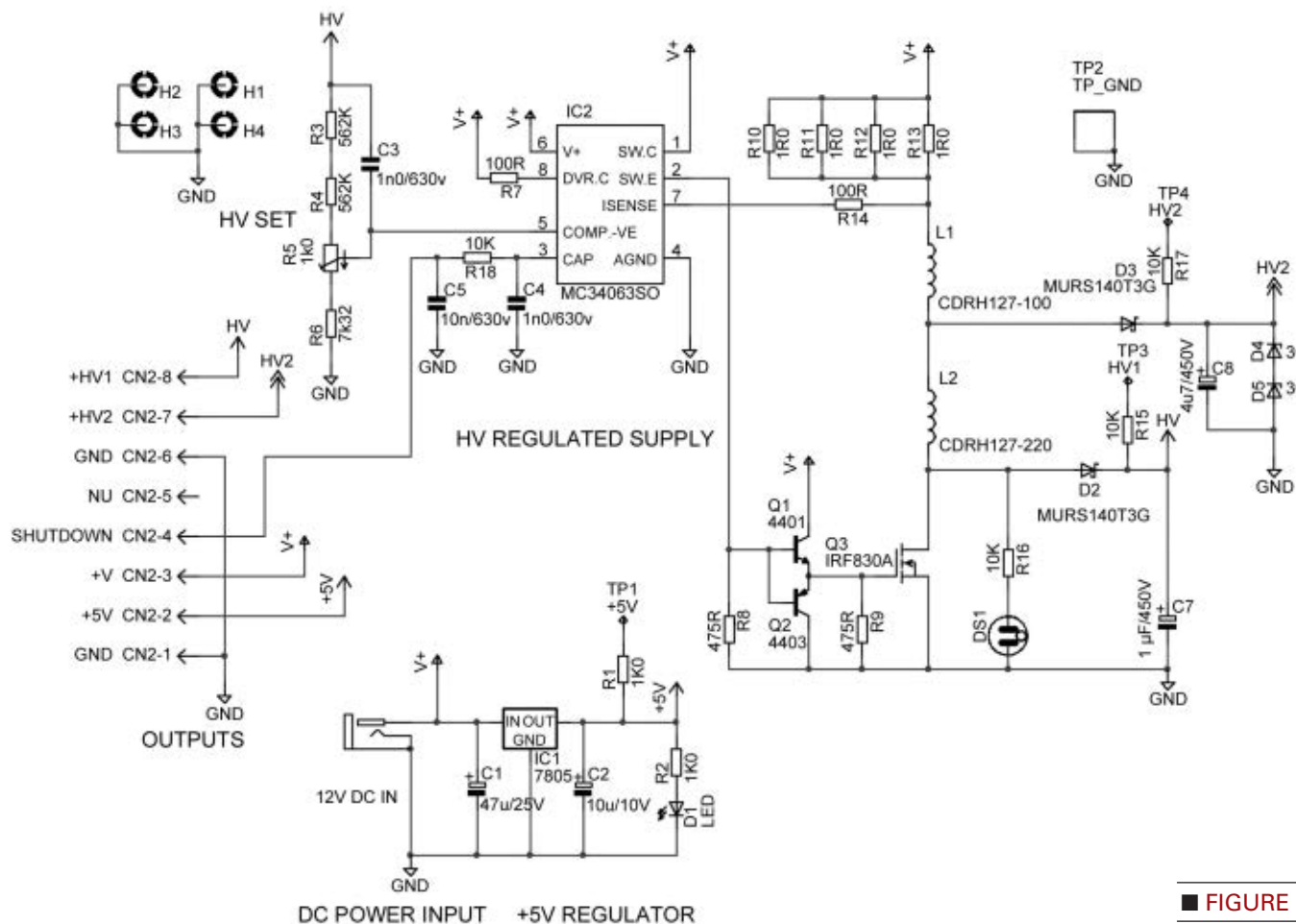
Output Limits:

Maximum current in regulation: 15 mA (enough for six medium to large tubes).

■ TABLE 1. Specifications.

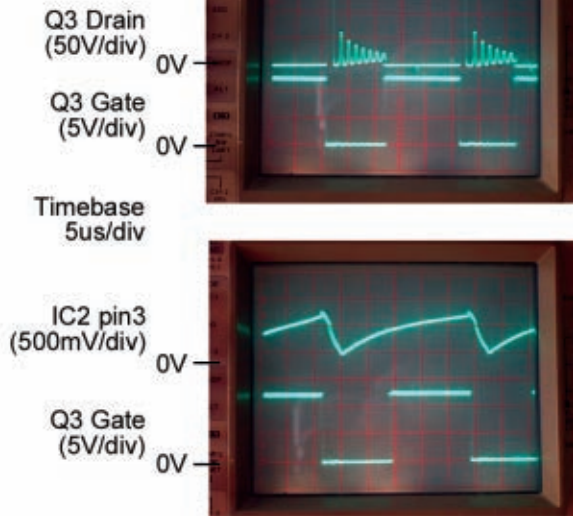


■ FIGURE 1. Photo of completed module.



■ FIGURE 2

■ **FIGURE 3. Scope waveforms.**



discovered (the hard way!) that test probes can be a hazard. To reduce the likelihood of shorting out power circuits with a careless slip of the probe, the test points are isolated with resistors (1K for low voltages and 10K for high voltages). TP1 monitors the 5V DC output.

DC input power is from a 2.1 mm coaxial jack, CN1, which mates to several commercially-made brick power supplies. All other connections are made through CN2, which can be a locking header (on the component side of the PCB) to mate with a wiring harness or an SIP header (on the solder side of the PCB) to allow the module to be piggy-backed on another PCB, a 0.1 inch perfboard, or a solderless breadboard.

Generating a 200V main output along with a second output of approximately 60V DC requires only one flyback converter stage. This was accomplished by tapping the inductor into “one third and two thirds” sections so that the 60V output can be derived from the tap. A commercial tapped inductor was not found, and homemade ones worked well but are messy, so two readily available inductors are used in series.

In any SMPS design, the components in the basic loop (see sidebar again) are under a lot of stress. Component types were carefully selected for the positions of D2, D3, L1, L2, and Q3 — please do not substitute! Ordinary rectifier diodes can’t be used for the HV

outputs; the type specified is a fast recovery diode.

Most of the work is done by a DC-DC converter control ASSP (Application Specific Standard Product), IC2. The MC34063 has been on the market for a couple of decades and is sourced by several vendors (and costs less than one dollar in hobby quantities!). As the IC was conceived in the days of power bipolar junction transistors — which are current-driven switches — this circuit requires another stage (Q1, Q2, R8, and R9) to drive the gate of a modern voltage driven PMOS FET transistor.

The main output (HV1) is controlled by a feedback loop that monitors the voltage developed on C7 and at TP3 through a resistor divider chain (R3, R4, R5, and R6). By making R5 a single turn potentiometer, the output voltage can be adjusted over a 15% range. C3 is included to improve stability, and the feedback resistor chain uses two resistors (R3, R4) to limit the voltage stress on each resistor (as I have found high value resistors to drift over time under high voltage stress).

Internally, IC2 generates a 1.25V reference, and this is compared to the voltage from the R5 wiper. Increased output demand lowers the voltage on C7 and the voltage at the wiper of R5, causing IC2 to increase the duration of the drive pulses to Q3. With greater energy stored in the inductor, the output rises to equilibrium again. When the output load is reduced, the opposite action occurs. Shorting or overloading the output is detected by the current limit circuit and the output voltage is allowed to safely fall.

Capacitor C4 controls timing of the internal ramp generator in IC2 at about 35 kHz. I discovered that if the voltage on this capacitor is taken slightly higher than normal, the IC will shut down with no risk of damage to it or other components. So, we have a simple way to shut down the HV using a 5V (or greater) signal on CN2 pin 4.

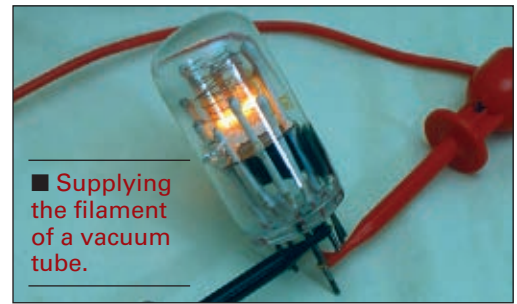
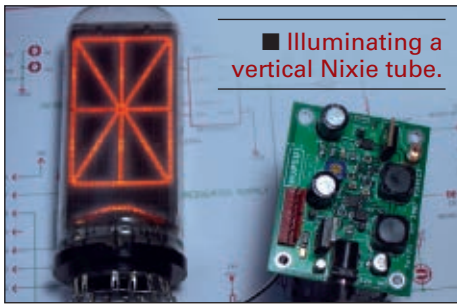
C5 and R16 filter any noise from the control line. When shut down, there is still a DC path through the inductor and diodes to the outputs, so the lowest output voltage is really that of the DC input supply (12V, in this case), which is true of all inductor based flyback designs.

Output from IC2 is applied to Q1 and Q2 to ensure that Q3 switches quickly and cleanly. Failure to turn Q3 on hard when the inductor is charging can lead to overheating in Q3 due to I^2R loss in the device. On the other hand, not turning Q3 off quickly can cause additional power loss in Q3. The parasitic capacitance from drain to gate in Q3 can cause the FET to turn on again mid cycle, usually with destruction of the device!

Unused energy from the inductor oscillates with stray capacitance and Q3 drain, causing ringing (see Figure 3).

Q2 clamps the gate to near ground during the off cycle, and Q1 sources current into the gate capacitance during the on cycle. Q3 lives a hard life with both high

V In	I In	P In	V Out	R load	I load	P Out	Eff
13.3	280 mA	3.72W	184V	15,520	11.86 mA	2.18W	58%
12.2	416 mA	5.12W	212V	15,520	13.66 mA	2.89W	56%
(Using Digi-Key T983-P5P-ND DC supply or equivalent.							
■ TABLE 2. Measured performances.							



FLYBACK THEORY OF OPERATION

A flyback converter is a member of a family of topologies called Switch Mode Power Supplies (SMPS) that are a variation on a basic circuit consisting of two switches, a magnetic storage component, and an electrical charge storage component. See Figure A. Both switches can be transistors, or more typically, a diode for the second switch (S2), an inductor for the first storage component (L), and a capacitor for the second storage component (C).

When the first switch is closed current from the input voltage is applied to the inductor, as shown in Figure B. Over time, the current in the inductor increases while energy is stored as a magnetic field. After a known time, the first switch opens and the second switch closes, connecting the inductor to the capacitor. The rapidly collapsing magnetic field drives energy from the inductor into the capacitor.

The duration for the first switch closure determines the amount of energy transferred. The rapidly collapsing field results in the output being greater than the input voltage, and of opposite polarity. This is therefore a step up topology. Because the common terminal of the inductor is connected to the input supply's positive side, the resulting output is now more positive than the input.

Another analogy is to consider a water bucket (the inductor) that is fed from a varying water stream. From time to time, we draw water from the bucket in a ladle of fixed size, so we get the same amount each time (output regulation). If we draw too often, the bucket may run dry, and if we stop drawing water with the ladle, the bucket may spill over. Clearly, the bucket and ladle sizes are critical! So it is in our SMPS where an inductor replaces the bucket and the output capacitor replaces the ladle.

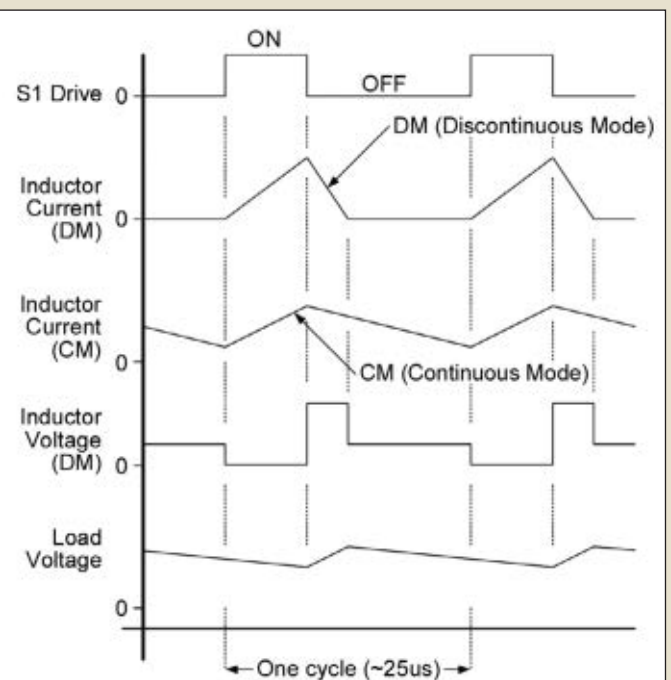
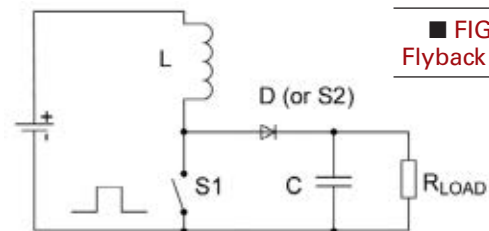
The term flyback refers to the fact that the collapsing magnetic field causes the coil to reverse polarity and generate higher voltage (than used to charge the inductor through the first switch). This effect is a problem when we drive a relay coil, so we add a flyback (or back EMF) diode to the coil to protect the driving circuitry from the negative high voltage spikes when the coil is turned off. Analog CRT displays (for TV or computer graphics) use a flyback transformer operating on the same principle to generate the high voltage needed by the CRT.

Transposing the first switch and the inductor produces a step-down topology — useful if we wanted a low voltage from a high input (rectified AC mains, for example). In each design, the inductor can be replaced by a transformer to give a greater ratio of input to output voltages, multiple outputs, and also provide

electrical isolation.

Finally, by comparing the output voltage to a reference we can change the timing of the switch closure to keep the output voltage nearly constant in spite of changing loads or changing inputs.

Flyback converters can operate in Continuous Mode (CM), where the inductor current never falls to zero, and in the Discontinuous Mode (DM) where the inductor current does fall to zero each cycle — once enough energy has been supplied to satisfy the load. If the load is too small, the converter is forced into the DM, which is a more difficult system to stabilize, and that is why some popular SMPS units found in PCs (a.k.a., Silver Box) require a minimum load for correct output regulation. The best efficiency and use of the physical inductor geometry is seen at the boundary of CM and DM.



■ FIGURE A. Flyback waveform diagrams.

voltage stress when off and high current stress when on. This lowers overall circuit efficiency along with core and winding losses in the inductors. Q3 does not require a heatsink, will not get warm at all, and is rated at 5A and 500V.

AC pulses on the drain of Q3 drive a small neon bulb, DS1, via R16, to indicate that high voltage is present.

When the module output is unloaded, IC2 will operate in DM (discontinuous mode) and the neon may flicker, which is normal.

The main output (HV1) is from C7, charged through diode D2 and monitored by TP3. The second high voltage output (HV2) is from C8 and TP4, charged by D3 from the inductor 'tap' and approximately one third of HV1. It will

CARE AND FEEDING OF NIXIE TUBES

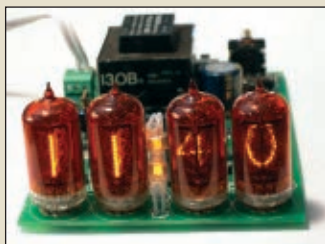
Burroughs Corporation was an early computer company that introduced the Nixie Numerical Indicator tube during the 1950s, although the design is attributed to the Haydu Brothers, who were already in business making electronic components and production tools for working glass. It is rumored that the Burroughs prototype was called "Numerical Indicator eXperiment 1" and the name 'Nixie' stuck. These devices were eventually displaced by lower voltage types (LCDs, LEDs, VFDs) that we know today, and US manufacture of Nixies ceased in the 1970s. There has been a hobby revival in using the original Nixie tubes and copies made by the Soviets (produced up until the late 1980s). See the resources list (Table A) for clubs and on-line discussion groups.

Most, if not all, experiments with Nixie tubes require around 200V up to about 10 mA. The original connection scheme applies high voltage to a single anode through a resistor (to limit the maximum current) and any one of the 10 cathodes is grounded through a switch or transistor. Glow discharge around the selected cathode shaped like a digit or letter makes a pleasing neon orange display.

There are vintage bipolar ICs from the DTL and TTL logic families of the 1970s to drive a single Nixie, but many experimenters roll their own circuits or adapt high voltage CMOS ICs to the task.

Nixie cathodes that are turned off have about 50V bias, requiring high voltage devices to drive the tubes. Some Nixie driving schemes require a second supply voltage around one third of the anode supply (i.e., 60V) to power the CMOS IC or aid in controlling the Nixie display when driven within a multiplex scheme. Multiplexed displays use fewer high voltage devices and save power, space, and cost for the project. Unlike radio tubes (used as amplifiers and oscillators, mixers, etc.), Nixie tubes are cold cathode devices and don't have heaters or filaments.

As Nixie tubes are no longer being made, to save the ones that we do have



it's wise to turn off the high voltage when it's not needed. In a Nixie clock, this can be done at night or during the workday when no one is around. Controlled by the time keeping circuit or a proximity detector, the display wakes up when people approach. This requires shutdown of the high voltage controlled by logic (5V) level, as featured in this project.

For most Nixie experimenters, it's easy to enhance a project with modern digital logic or microcontroller circuitry, which is geared to a 5V DC supply and was also added to this project.

Nixies found as NOS (New Old Stock) may suffer from storage damage and not work correctly. Often these tubes can be revived with a steady current above the normal design rating, applied for many tens of hours until the digits "clean up."

I built my first HVPSU to test unknown Nixies found at hamfests or pulled from dead equipment. The project described here is ideal for off-line Nixie testing, burn-in, and recovery.

Yahoo Group	Electron Tube Chronicles (eTC)
URL	http://groups.yahoo.com/group/electrontubechronicles
Contact	electrontubechronicles-subscribe@yahoogroups.com
Comments	Virtual club (Yahoo only) for collectors and experimenters of specialty tubes/valves. Interesting photo section of strange and unusual tubes. Founded in 2004, currently about 150 members. Free (requires a Yahoo UserID).
Yahoo Group	Neonixie-L
URL	http://groups.yahoo.com/group/NEONIXIE-L
Contact	NEONIXIE-L-subscribe@yahoogroups.com
Comments	Virtual club (Yahoo only) originally for Nixie clock fans, but frequently off topic, helpful to electronics experimenters. Great photos section of member's projects and datasheets, schematics, etc. Founded in 2002, currently about 1,800 members. Free (requires a Yahoo UserID).
Yahoo Group	tubecollectorsassociation
URL	http://groups.yahoo.com/group/tubecollectorsassociation
Contact	tubecollectorsassociation-subscribe@yahoogroups.com
Contact	www.tubecollectors.org
Comments	A real club (not-for-profit 501(c)(3) status) with quarterly paper magazine and annual meetings. Very knowledgeable members and club possession of tube factory archives, databases, and libraries. Founded as a Yahoo Group in 1999, currently about 330 members. Free on-line access (requires a Yahoo UserID). Club membership fees are \$20 per year.

■ TABLE A. Tube Collector Resources.

climb slightly when HV1 is loaded (due to the feedback loop around HV1), so Zener diodes D4 and D5 clamp the HV2 output at 60V nominal (57V to 63V); I used two diodes to spread the dissipation in these tiny SOT23 size parts.

Inductor current is monitored by a low value resistor at the top end and the sawtooth waveform is fed back to IC2 by R14. Because low value SMT resistors are expensive, I used a parallel network of several one ohm 1206 size resistors. Luckily, a partially used reel of "1R0,

1206, Qty 5,000" was found at the local surplus emporium for a couple of dollars and will last me for a lifetime!

PCB Assembly

A PCB is recommended for construction, although I built prototypes on perfboard using mostly TH parts. Layout is not critical but it aids in getting good performance and reliable operation of high voltage circuits. Care is required in directing ground currents

PARTS LIST

ITEM	VALUE	MOUSER PART #	DESCRIPTION
□ C1	47u/25V	5985-AFK25V47-F	CAP 47μF 25V ELECT VS SMD
□ C2	10u/16V	5985-AFK25V47-F	CAP 10μF 16V VS ELECT SMD
□ C3	1n0/630V	81-GRM31BR72J102KW01	CAP 1000pF 630V CERAMIC X7R 1206
□ C4	1n0/630V	81-GRM31BR72J102KW01	CAP 1000pF 630V CERAMIC X7R 1206
□ C5	10n/630V	810-C3216X7R2J103K	CAP .01μF 630V CERAMIC X7R 1206
□ C7	4u7F/450V	647-UVZ2W4R7MPD	CAP 4.7μF 450V ALUM LYTIC RADIAL
□ C8	1uF/450V	647-UVZ2W010MPD	CAP 1.0μF 450V ALUM LYTIC RADIAL
□ CN1	DC-JACK	806-KLDX-0202-A	CONN JACK POWER 2.1MM PCB
□ CN2	22-27-2081	538-22-27-2081	CONN HEADER 8POS .100 VERT TIN
□ (Alt)	22-03-2081	538-22-03-2081	CONN HEADER 8POS .100 VERT TIN
□ D1	YELLOW LED	859-LTST-C150KSKT	LED YELLOW CLEAR 1206 SMD
□ D2	MURS140T3G	511-SMBYT01-400	DIODE ULTRA FAST 1A 400V SMB
□ D3	MURS140T3G	511-SMBYT01-400	DIODE ULTRA FAST 1A 400V SMB
□ D4	MMBZ5256	621-MMBZ5256B	DIODE ZENER 30V 350mW SOT-23
□ D5	MMBZ5256	621-MMBZ5256B	DIODE ZENER 30V 350mW SOT-23
□ DS1	NE2MINI	606-2ML	Neon 65VAC .3mA NE-38S
□ IC1	L7805	511-L7805CV	IC POSITIVE REG 5V TO-220FP
□ IC2	MC34063SO	863-MC34063ADR2G	IC REG SW DC-DC INV 1.5A 8SOIC
□ L1	CDRH127/LDNP-101MC	851-CDRH127LDNP101MC	INDUCTOR 100μH 2.1A SHIELD SMD
□ L2	CDRH127/LDNP-221MC	851-CDRH127LDNP221MC	INDUCTOR 220μH 1.45A SHIELD SMD
□ Q1	MMBT4401	512-MMBT4401	TRANSISTOR GP NPN AMP SOT-23
□ Q2	MMBT4403	512-MMBT4403	TRANSISTOR GP PNP AMP SOT-23
□ Q3	IRF830A	844-IRF830APBF	MOSFET N-CH 500V 5A TO-220AB
□ R1	10K	660-RK73H2BTTD1002F	RES 10.0K OHM 1/4W 1% 1206 SMD
□ R1	1K0	71-CRCW1206-1.0K-E3	RES 1.0K OHM 1/4W 1% 1206 SMD
□ R2	1K0	71-CRCW1206-1.0K-E3	RES 1.0K OHM 1/4W 1% 1206 SMD
□ R3	562K	660-RK73H2BTTD5623F	RES 562K OHM 1/4W 1% 1206 SMD
□ R4	562K	660-RK73H2BTTD5623F	RES 562K OHM 1/4W 1% 1206 SMD
□ R5	1k0	652-3306P-1-102	POT 1.0K OHM 6MM CERMET TOP TRIM
□ R6	7k32	660-RK73H2BTTD7321F	RES 7.32K OHM 1/4W 1% 1206 SMD
□ R7	100R	71-CRCW1206-100-E3	RES 100 OHM 1/4W 1% 1206 SMD
□ R8	475R	660-RK73H2BTTD4750F	RES 475 OHM 1/4W 1% 1206 SMD
□ R9	475R	660-RK73H2BTTD4750F	RES 475 OHM 1/4W 1% 1206 SMD
□ R10	1R0	660-RK73H2BTTD1R00F	RES 1.0 OHM 1/4W 1% 1206 SMD
□ R11	1R0	660-RK73H2BTTD1R00F	RES 1.0 OHM 1/4W 1% 1206 SMD
□ R12	1R0	660-RK73H2BTTD1R00F	RES 1.0 OHM 1/4W 1% 1206 SMD
□ R13	1R0	660-RK73H2BTTD1R00F	RES 1.0 OHM 1/4W 1% 1206 SMD
□ R14	100R	71-CRCW1206-100-E3	RES 100 OHM 1/4W 1% 1206 SMD
□ R15	10K	660-RK73H2BTTD1002F	RES 10.0K OHM 1/4W 1% 1206 SMD
□ R16	10K	660-RK73H2BTTD1002F	RES 10.0K OHM 1/4W 1% 1206 SMD
□ R17	10K	660-RK73H2BTTD1002F	RES 10.0K OHM 1/4W 1% 1206 SMD
□ R18	10K	660-RK73H2BTTD1002F	RES 10.0K OHM 1/4W 1% 1206 SMD
□ TP1	+5V	534-5001	TEST POINT PC MINI .040"D BLACK
□ TP2	TP_GND	(Construct from 22 AWG tin copper wire)	
□ TP3	HV1	534-5001	TEST POINT PC MINI .040"D BLACK
□ TP4	HV2	534-5001	TEST POINT PC MINI .040"D BLACK

around Q3 and the inductors, to keep the high voltage pulses out of the sensitive feedback loop near IC2.

The recommended PCB has both TH and SMT parts; the PCB design files are available on the *Nuts & Volts* website (www.nutsvolts.com). SMTs can be hand-soldered, just like the TH parts, and a few components are installed on the 'solder side,' so do these first and continue with the other SMTs on the component side next. Leave Q3 off until after initial testing. I'm switching over to SMT parts for hobby projects and discovered that brand new SMT resistors (above 10 ohms) are so cheap that 1% tolerance parts are economical, hence the unfamiliar values on some resistors. The ground test point is fashioned from a piece of tinned copper wire (possibly salvaged from a TH resistor), and makes a great way to hold the mini croc-clips on scope probes.

Power Up Testing

Leave Q3 off the PCB to allow the low voltage regulator to be tested first. If a scope is placed on the Q3 gate pad, a clean square wave drive will confirm that IC2 and related circuits are working correctly. Until Q3 is installed, no high voltage will be generated. Check the 5V output with a DMM (it should be 4.75V to 5.25V).

Install Q3 and check HV1. Adjust R5 over the full

range and confirm it covers approximately 175V to 200V. Finally, check HV2 which should be no more than 63V, and typically a little less until the HV1 output is loaded up.

For a regulation check, use a dummy load of 18K 2W on the HV1 output. Or, use a chain of eight 1/4W 18K resistors in series and parallel if high power resistors are not available. Finally, take CN2 pin 4 to 5V and confirm that the HV shuts down. (Remember, photos of the typical scope waveforms are shown in Figure 3.)

Other Uses

The circuit and layout presented here are my "Mark III" design as the two earlier versions paved the way. Areas of interest to me are increasing the switching frequency (from 35 kHz to, say, over 100 kHz) and experimenting with current-mode feedback that should offer better transient load regulation than the voltage mode used by the MC34063 IC. Several modern ASSPs are available for the control loop.

For tube experiments where a heater supply is needed, the 5V regulator (IC1) can be replaced with a 6.0V type, which slightly under runs a standard 6.3V heater at 95%. A heatsink will be required for IC1, and a stronger AC power brick. The output voltage can be changed by using a different value for the pot (R5) and

R6, respectively. The main feedback resistor chain (R3, R4) should be kept at approximately one megohm (1,124K with specified components); the upper limit is the breakdown voltage of D2, D3, and Q3, so stick to 250V or lower. Use the following formula to calculate a new output voltage:

$$V_{out} = 1.25 * ((R3 + R4 + (R5/2) + R6) / (R6 + (R5/2)))$$

To calculate a new value for R6 for a given output voltage:

$$R6 = ((R3 + R4 + (R5/2)) / ((V_{out}/1.25) + 1)) - (R5/2)$$

Enter these directly into an Excel spreadsheet to experiment with the center, min, and max range of the trim pot, R5. Or calculate the resistors required for a desired output. The voltage reference in IC2 is good to 2% tolerance. **NV**

The PCBs and/or a complete kit for this project can be purchased through the *Nuts & Volts* Webstore.

WWW.POWERWERX.COM
POWER CONNECTOR SUPERSTORE
Standardize Your Power Connectors
Best choice for New Hams
 Share Emergency Power • Reusable • Easy to Use
 Anderson Powerpoles®, Adapters & Accessories

VeriSign®
 Easy secure online ordering

Authorized RIGblaster & RIGrunner Dealer

powerwerx.com

Huge savings • lowest prices
 Over 1500 products in stock • Satisfaction guaranteed!

Build your own or buy assembled

BY MICHAEL SIMPSON

NIAGARA IV INK FLOW SYSTEM



I have been interested in photography since I was a teenager and I remember the early days of color slide processing. Things have definitely come a long way since then. While the costs of the digital cameras have dropped, the quality of the photos produced has increased. In this series, I will show you how to create some cool electronic projects that will allow you to control your camera in ways you may find very useful. Along with these projects, I will also show you how to use a couple of products that you probably didn't know existed.

The quality of photo printers has finally reached a point that you can now print a picture that will match the quality of any printing service. As a matter of fact, I recently dropped off a roll of film to a rather reputable printer and was amazed at their low quality. Almost all the pictures had dust specs.

Unfortunately, if you have done any ink jet printing you will quickly find out that the cost of ink is outrageous. It's a known fact that the printer manufacturers make their money on the inks they sell. In the past, you could purchase one of those refill kits and it would save you about half the cost of the original ink. The problem with this is that it can get messy, and the manufacturers are starting to place electronic chips in the cartridge that counts the ink drops. These cartridges will

no longer function after a certain number of drops. Some manufacturers have even gone so far as to limit the age of the cartridge, as well. It has gotten so bad that at least one manufacturer now licenses the use of the cartridge and considers its reuse a breach of copyright.

I started printing several 4x6, 5x7, and 8x10 prints and after just a few, realized it would be much cheaper to just take them to my local printer. While searching the Web, however, I came across the Niagara Continuous Ink Flow System.

The Niagara system allows you to add external ink tanks to your ink jet printer. This does three things:

- 1) You don't have to change cartridges.
- 2) The cost of ink is a fraction of what it used to be.



■ **FIGURE 1. Vials of replacement ink just waiting to keep the new cartridges topped off!**

■ FIGURE 2



3) You save our landfills as you won't buy another ink cartridge.

I decided to purchase an inexpensive photo printer in order to put the Niagara system to the test. I decided on an Epson Stylus Photo R380, shown in Figure 2. The printer sells for around \$110, and of all the printers I tested in this price range, it gave the best results. It was also compatible with one of the Niagara systems. I



■ FIGURE 3



■ FIGURE 4

purchased the printer locally and ordered my Niagara system from MediaStreet. (You will find MediaStreet at www.mediastreet.com)

While I waited for my Niagara system to arrive, I decided to do some test prints to get an idea of per print costs on the printer. I printed several 4x6 photos, which included a good mix of landscapes and portraits. After 75 prints, the Epson printer driver reported that two cartridges were out of ink, and it would not let me continue until I replaced them with new ones.

The cartridges cost around \$14-\$19, depending on where you purchase them. This calculates to about \$.37 per photo not counting the cost of paper. I can get some rather nice prints done in about an hour at my local Costco for \$.17 each, and that includes the paper. This cost difference is why I normally have my photos printed out somewhere.

What is the cost of the using the Niagara IV Continuous Ink flow System? Let's do some math. Each Epson R380 cartridge holds .25 oz of ink and we used two cartridges. Based on tests, the printer used .0067 oz of ink per print. That's 597 prints per 4 oz bottle of MediaStreet ink. The cost of a 4 oz bottle of the ink used in the R380 kit is \$8.91 per bottle. That calculates to \$.015 per 4x6, print. Yes, that's right, less than two cents of ink per print. An 8x10 will cost you about \$.05 per print.

Why such a dramatic difference? It's a common fact that the printer manufacturers make their money on the consumables. They could give the printers away and still make a profit. Also, the Epson cartridges still had ink in them even though the printer driver marked them as used up.

The Niagara system is not a cheap upgrade. In fact, the system cost me more than I paid for the printer. The cost of the Niagara system with ink cost me approx \$178 plus shipping. While this cost may seem excessive at first, consider that after about 12 cartridges, it will have paid

for itself. If you do a lot of printing, you will definitely reap the benefits. In my case, mine was paid for in less than a month of use.

My Niagara system arrived in about five days and included the Epson R380 Niagara Ink Flow system shown in Figure 3, and the six 4 oz bottles of plug and play ink shown in Figure 4.

The Niagara IV continuous Ink Flow System comes with the following items (shown in Figure 5):

- Six empty ink tanks connected to six empty ink cartridges via a small tube cable
- Pair of latex gloves
- Paper towels
- Plastic syringe
- Set of six small intake filters
- Center bracket
- Funnel

The ink cartridges are special ones that keep the Epson system from marking the cartridges as used up.

Filling the Tanks

The tanks need to be filled before they are inserted into the printer. I recommend placing some newspaper down as extra protection for your workspace. Even though I was very careful, I did spill a few drops of ink.

My main complaint about the Niagara IV system is the quality of the instructions. They are very generic with very few pictures. Most of the pictures included do not even apply, as the instructions are intended to be used with all printers.

Let me guide you through the process of upgrading the Epson R380 printer.

- **STEP 1:** You will need to fill each tank and bleed the cartridge one at a time. In other words, do the yellow first, and then move on to the black once it is finished.

Pick a color and fill the tank. In this case, I am working on the color Black. Fill the tank by removing the large plug and inserting the funnel. Open the ink jar and fill the tank about 3/4 full as shown in Figure 6. The instructions state to fill to the 3/4 mark, but I couldn't find a mark, so I just took a guess. Once



■ FIGURE 5

filled to the indicated level, remove the funnel and place it inside the ink jar since you will be using it again shortly. Plug the large hole and leave the small hole unplugged.

- **STEP 2:** With the syringe plunger fully inserted into the syringe, insert it into the bottom exit port of the color chosen. You will have to break the seal of the plastic tape that covers the hole. I just applied pressure with the syringe until the seal was broken. I then twisted the syringe back and forth until the syringe was through the rubber valve. Next, you pull up on the plunger. This will pull ink from the tank through the tube and into the cartridge. Once the plunger gets near the top, pull the whole syringe out of the hole and push the plunger back to the bottom and repeat until you pull a steady stream of ink into the plunger as shown in Figure 7. I tilted the cartridge slightly in order to remove as much of the air



■ FIGURE 7



■ FIGURE 6



■ FIGURE 8



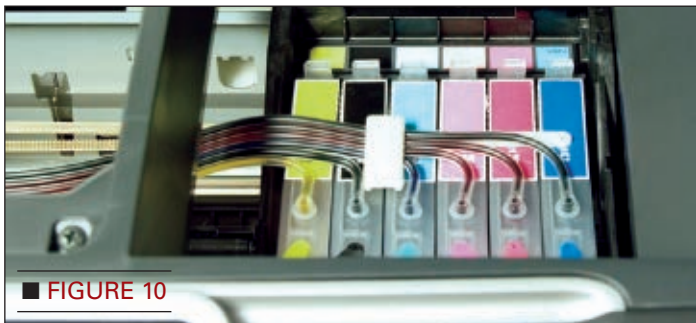
■ FIGURE 9

as possible. Keep in mind that it is almost impossible to remove all the air.

- **STEP 3:** Remove the syringe from the exit port and squirt any ink in the syringe back into the ink bottle. Open the large fill hole and refill the tank back to the 3/4 mark. Plug the fill hole and place one of the filters into the tank filter hole as shown in Figure 8. Once all the tanks have been filled, you are ready to insert the cartridges into the printer.

Installing the Ink Cartridges

- **STEP 4:** The cartridge cover on the printer must be



■ FIGURE 10



■ FIGURE 11

removed in order for the Niagara system to work properly. The instructions given with the system do not apply to the Epson R380. The only way I could make it work was to pry the small tab up using a screw driver as shown in Figure 9. Please note that in order to remove the tab I had to break it, so removal of the cartridge cover is permanent.

- **STEP 5:** This is the point where the included instructions start to get confusing. To install my cartridges, I turned the printer on and told it I wished to change a cartridge. This moves the cartridge tray into an accessible position. I then removed the power cord from the printer and by hand moved the tray all the way to the left. This allowed me to insert the six replacement cartridges through the center opening then back up through the right opening. I then moved the tray back to the right and inserted the cartridges as normal as shown in Figure 10.

- **STEP 6:** It's now a simple step to place the center bracket dead center on the printer as shown in Figure 11. Place the additional hold-down clamp on the right as shown. Unfortunately, once the system is in place, the cover no longer closes properly as shown in Figure 12. This concerned me since dust could now get inside the printer.

To remedy the problem, I took a 1/8" strip of plastic and mounted one of the small clamps that came with the Niagara on the underside of the strip as shown in Figure 13. I then used double-stick carpet tape to hold the strip and tubing. I now can close the lid almost all the way.

How Well Does the Niagara IV Work?

One of the features of the Epson R380 is the Claria ink. While I no longer use the Claria ink, I have found the prints to be indistinguishable from those made with the original ink.

My main goal was economy, so I visited a couple of my local stores and purchased some of the cheapest 4x6 printer paper I could find (see Table 1).

All the papers tested well. The JetPrint Everyday and Staples Photo Supreme Satin were the only non-glossy papers tested. They both had a slight green tint.

The worst paper was the JetPrint Premium. These would not hold the ink and beaded up when used with the original Epson Claria Ink. Even after weeks they remained tacky. The Niagara system did much better with this print. The prints were clear and were dry in 24 hours. They did, however, leach ink days after the print was made.

The LexMark and Kirkland papers were constant favorites. With the Kirkland 5¢ price per sheet, I consider it the best bang for the buck. Using this paper, at the most it will cost only 7¢ per photo on average.

I printed well over 1,000 4x6 photos and over 100 8x10 photos, and am still on my original ink set. The only colors that show any amount of use are the Yellow, Light Cyan, and Light Magenta. My estimate is that I have used under \$17 in ink. This is actually under my original calculations. I am sure as I use more ink I will get a much better handle on the actual costs and am sure I will be quite happy with the results. MediaStreet sells 4 oz, 8 oz, 16 oz, and 32 oz bottles of ink. Using the larger bottles will save you even more.

The folks at MediaStreet have advised me that the Ink used in this kit will act much like standard ink and won't hold up to the claims of the Epson Claria. Keep in mind that when it comes to ink, the claims from manufacturers regarding longevity have yet to be proven.

The bottom line is that if you want to print fine art that will last 100s of years, you should probably look at a pigment printer and pigment ink. For dye-based inks, the Niagara IV Ink Flow system presents the best economy I have ever seen. As for the pigment printers, there are Niagara systems for those, as well.

If you decide to go with a pigment-based printer, MediaStreet sells a pigment-based system called the Niagara V.

Closing Thoughts

I did have to raise my printer an inch off of the table because I was getting excess ink on the backs of the prints and some spattering on the

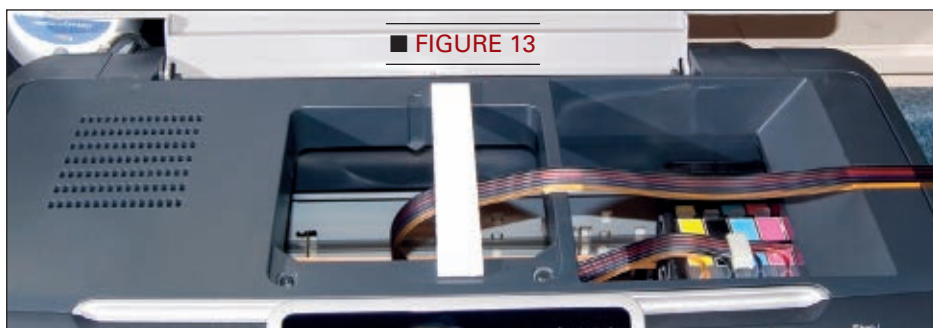
Name	Cost Sheet
Epson Premium Photo Glossy	Qty 100 14¢ each
JetPrint Everyday	Qty 100 16¢ each
JetPrint Premium	Qty 100 18¢ each
JetPrint Professional	Qty 100 27¢ each
Kirkland Professional Glossy	Qty 300 5¢ each
LexMark Photo Glossy	Qty 100 10¢ each
Staples Photo Supreme Satin	Qty 100 12¢ each
Staples Photo Basic Glossy	Qty 200 9¢ each

TABLE 1. 4x6 paper tested.

front. The height adjustment has solved my problems, but your exact results may vary depending upon your altitude. You start by making both the bottom of the printer and ink tanks at the same height, then adjust one or the other based on some testing over time. If you are getting excess ink on the prints, raise the printer. If the tanks are not able to supply the printer, raise the tanks.

Next Time

I want to show you a couple cool programs that are available for your camera. I will also start with an interface that will allow you to control your camera with a microcontroller. With this interface, we will be able to build sonar, remote control, and time lapse projects. How about a lightning detector to help you with capturing some great storm effects? **NV**



LINKS

MediaStreet
www.mediastreet.com

Epson
www.epson.com

HOUSEHOLD THERMOSTAT AND HEATING/COOLING CONTROL

BY CHUCK IRWIN

Build this PIC-based thermostat and heating/cooling control box and take control of your household environment.



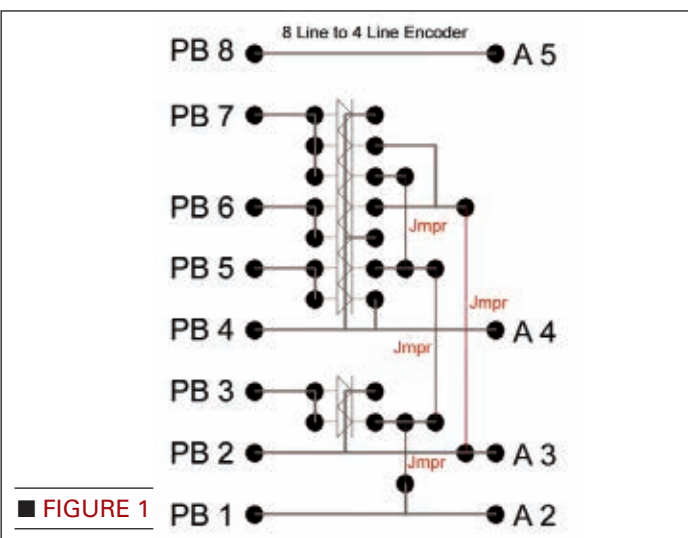
I have always been very interested in thermostatic controls for heating and cooling systems. I presently have a simple thermostat control, which only shows the measured temperature, the set temperature, and has the ability to set the desired temperature. In addition, a heating/cooling switch, on/off switch, and a fan switch are provided, which is typical.

A PIC is an ideal device to build a controller, plus it is possible to program it to give more functions. The unit described in this article features: display of a real-time clock; two settable temperatures; two settable time periods; a heating/cooling switch; an on/off switch; and a fan switch. I used a 16F870 PIC because it is not only inexpensive, it features an analog input port for reading the temperature sensor (LM34) and 21 other input/output ports. Some of the ports were programmed to be input/output ports to support the 10 pushbutton switches to control the unit. The remaining 11 ports were used to control a two-line, 24 character LCD display.

When I first discovered PICs, I decided I would try to find the best PC program to write and construct working

PIC programs, including the ability to diagnose and repair any problems as easily as possible. I tried some of the free programs. I tried some of the less expensive programs, and even tried to write programs using the basic PIC assembly commands. I found it very difficult to keep track of all the different "housekeeping" functions. I finally decided to try the PICBASIC PRO program and that is when I had my best success.

It has very intuitive commands and keeps track of all the housekeeping while allowing the programmer the capability to troubleshoot programs on-the-fly. Of course, when I decided to purchase the full functioned program, I



■ FIGURE 1

had to save my pennies because the price tag was around \$250. In addition, the PICBASIC PRO program is enhanced considerably by the Mechanique Microcode Studio Plus Graphic User Interface (GUI) program, and that was approximately another \$50.

I do not regret one penny of the money I spent. I recommend these two programs to anyone that wants to get into the PIC world. The two programs are available from **www.melabs.com**.

I have included all of the PICBASIC PRO program files generated from the original program I wrote (8BitTstatRTClk2.bas) – which also includes the 8BitTstatRTClk2.hex file – on the *Nuts & Volts* website at **www.nutsvolts.com** under ThrmStatNVFiles.zip. In addition, all of the data sheets and figures from this article are included.

Any PC based PIC software may be used to program the hex code into a 16F870 PIC. I'm sure any readers who are programmers would be able to write their own version or modify the program to do additional functions. My program takes care of the functions listed below and displays them on the LCD display:

- 1) Measured Temperature (Tm)
- 2) Set Temperature (Ts)
- 3) Second Set Temperature (T2s)
- 4) Real Time Clock showing Hours, Minutes, and Seconds
- 5) Start Time for the second Set Temperature (T2S)
- 6) End Time for the second Set Temperature (T2E)

Ten different pushbuttons on the front of the unit can adjust all of the above functions. There is a pushbutton for each of them, including degrees, hours, and minutes plus one pushbutton to increase the value and one to decrease the value. If the power goes off and comes back on again, the program is set to default which is the following:

- 1) Set Temperature to 55 degrees (Ts)
- 2) Second Set Temperature to 57 degrees (T2s)
- 3) Clock to 12:00 (Noon) (Format is 24 hours)
- 4) Second Set Temperature Start Time to 23:30 (11:30 PM)(T2S)
- 5) Second Set Temperature End Time to 07:30 (7:30 AM)(T2E)

During the periods other than the second Start/End Times, the temperature will be set to the first Set Temperature (Ts).

How Does it Work?

The first problem was finding the programming to produce a real-time clock within the PIC to control the times needed for the heating/cooling functions in the house climate control unit. I was able to find a lot of help for PIC programming using the PICBASIC PRO program forum at **www.picbasic.co.uk/**

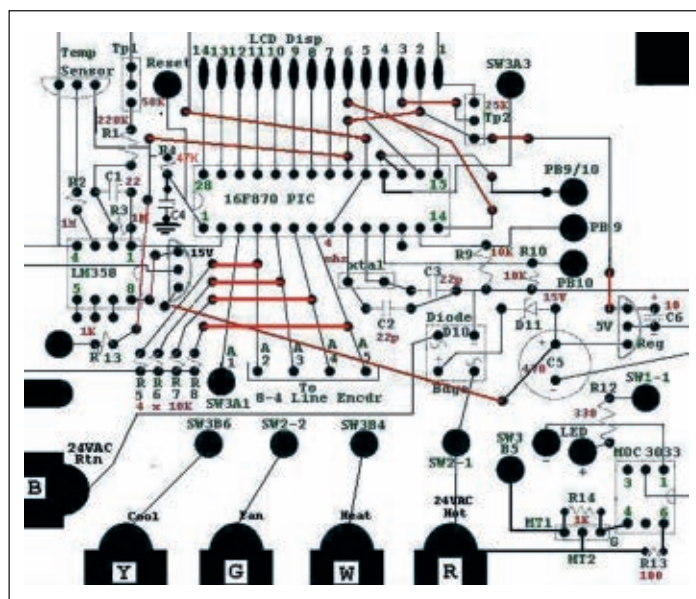
forum, which is hosted by Crownhill Associates and entitled MELabs PICBASIC Forum. Most of the help provided revolves around the syntax used by the PICBASIC PRO program. There are quite a lot of intelligent programmers providing all kinds of information and answers at that website. One answer which I really needed for this project (and found on the website) was programming for a real-time clock. The programming was initially done by **www.romanblack.com**, and converted to PICBASIC PRO syntax by Paul R. Borgmeier at **www.cruxanalysis.com**. The program is amazingly simple using a series of "If.....then" statements and one of the PIC's internal timers.

The second problem to solve was taking the input from the LM34DZ temperature sensor and converting it into a corresponding readout on the LCD. After doing some experimentation, I found that setting the program to give a 10 bit representation of the results, setting the PIC to use its own internal RC oscillator for analog-to-digital conversion, and allowing the PIC to sample the input every 50 microseconds gave the best results.

With an input of .515 volts to the analog input of the PIC, the display shows 103, which is double the input voltage. Since the LM34DZ puts out .01 volts for each degree of temperature, a temperature of 56.4 degrees will give an output of .564 volts from the LM34. The PIC, on the other hand, works best with voltages between zero and five volts. Using an op-amp to multiply the LM34DZ output by five gives an exact indication of the temperature on the LCD display.

For example, suppose the temperature is 64.3 degrees. The output of the LM34DZ will be .643, multiplying that by five gives 3.215. The PIC multiplies that by two without any extra programming and displays 643 on the LCD. I could have had the display show 64.3, but I decided to leave out the decimal point to give a more comfortable spacing on the LCD.

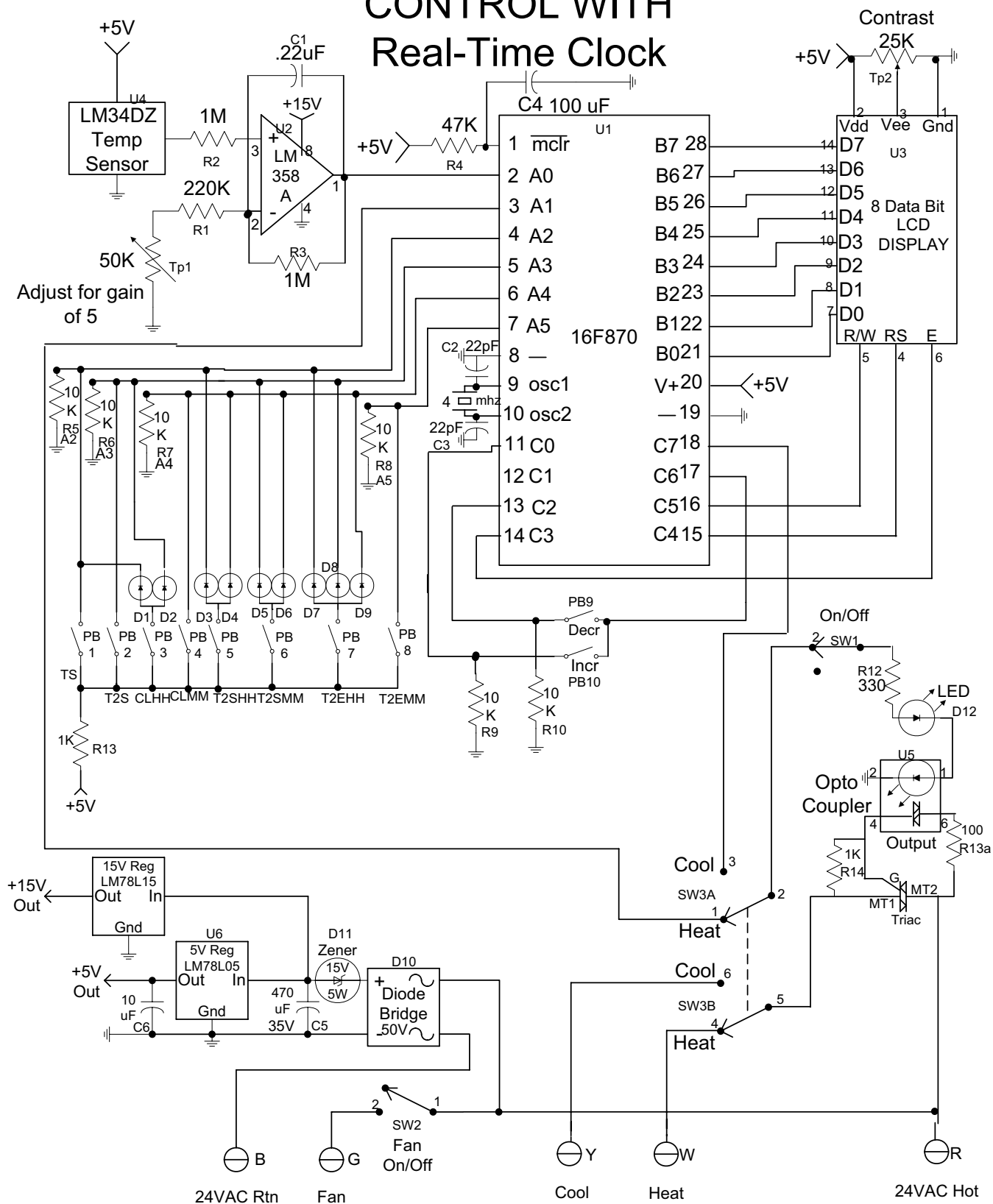
I did note an anomaly with the analog/digital



■ FIGURE 2

■ **FIGURE 3**

THERMOSTAT CONTROL WITH Real-Time Clock





■ FIGURE 4



■ FIGURE 5

converter on different 16F870 PICs. They tend to show anywhere from .1 degrees to 1.5 degrees high or low from the actual temperature measured by the LM34 sensor. The 16F870 chip I used in my unit indicated a temperature of .8 degrees higher than from the LM34 sensor. I added an extra step in the program to correct for this.

In the program, I have included this step, but you may have to change that value depending on the measurements you note in your own unit.

In the rich text format version of the program (8BitTstatRTClk2.rtf), that line is shown in red. There are more details on this available from the file on the *Nuts & Volts* website.

The third problem to solve was multiplexing the input signals to only use up to four ports on the PIC (there are eight for each of the function inputs). I used diodes to convert each pushbutton input to a binary number. That worked well because with four inputs, a maximum count of 16 can easily be represented, i.e., 2 to the fourth power, or binary 1111 (see Figure 1). The printed circuit board (PCB) for this encoder is also available on the website.

The fourth problem was getting a pulse every second, but getting it short enough to only increment or decrement the functions once per second. Since the main clock loop in the program loops through every .065536 seconds, the pulse width had to be the same length. To get the pulse out of the PIC once per second required a timing loop to count from 0 to 15 and give a high pulse on only one of those loops. (See the text version of 8BitTstatRTClk2.txt; the last item in the program shows how this was done.)

The final problem was converting the +5 volts output from the PIC output port to control the 24 volts AC to the heating/cooling relays. That was accomplished using an MOC3033 opto-coupled, zero-crossing detector triac to control a higher power triac to switch up to one amp of current into the 24 VAC heating/cooling relays.

Construction and Connections

Since I only needed to make two PCBs (thermostat and eight line to four line encoder), I first cut the double

copper clad PCBs to the correct dimensions; 3.7" x 3.1" for the thermostat board and 1.7" x 1" for the encoder board. I then printed out the patterns (available on the NV website) using the program *Irfanview.exe* (a free graphics program available from www.irfanview.com). This program allows you to specify the exact size of the finished print which — unfortunately — was NOT exact when it printed. I had to set the dimensions to 3.705" x

WHY USE THE 16F870 PIC?

1) It is inexpensive (less than \$5) and readily available from many popular vendors; i.e., www.mouser.com, www.microchip.com, and www.melabs.com, and is easily ordered via the Internet.

2) It features two full eight-line input/output ports and one five line input/output port.

3) It features optional analog-to-digital conversion on the five-line port, enabling inputs from any analog sensor configuration with 10 bit, 50 microsecond resolution.

4) It features a reduced set of only 35 instructions for programming and is easily accommodated by most of the currently available PIC compilers and programmers. The free program, MPLAB IDE (available from www.microchip.com), may be used to construct a programmable hex file for the PIC from assembly language programs you can write yourself. Go to www.microchip.com and do a site search for MPLAB IDE; this takes you to a page with the software download at the bottom of the page.

5) Information for the PIC is readily available from many sources on the Internet; i.e., www.melabs.com, www.sq-1.com, www.mouser.com, and www.microchip.com.

6) It has many other features which are outlined in the first pages of its data sheet (16F870,871.pdf), available on the *Nuts & Volts* website (www.nutsvolts.com) and listed under this article.

7) Last but not least, it is possible to use two 16 pin DIP sockets in line to accommodate it. The RadioShack locations carry these sockets but not the 28 pin DIP sockets.

3.105" to make the printed version exact (the IC holes need to be exactly .100" apart).

The PCB holes were then drilled by laying the templates over the boards and drilling through the templates. I then hand drew the circuit on the LAN side of the boards using fingernail polish. The boards were then

turned over to the component side and all of the connection pads were drawn with fingernail polish (Figure 2). I used a 1/8" drill to counter sink all of the holes on the component side of the boards. This results in an effective ground plane after all unused spaces on both sides of the board are covered with fingernail polish. After that, one hour in the ferric chloride solution (available from RadioShack, part 276-1535 for about \$5), and the boards were etched and ready for component mounting and soldering.

Before mounting any components, it is necessary to run small pieces of #30 bare copper wire through all of the pad connections and solder everything to both sides. This gives a through-board connection for all the pads on the component side of the board.

The connections to the unit are made on the main PCB and are done with homemade terminal screws. These were constructed using the double-sided PCB with 6-32 nuts soldered on one side of the board, and the 6-32 x 3/8" bolts going through on the opposite side. The connections to the board are wires coming out of the wall, going through a hole in the back of the unit.

My old thermostat used the following connections from the house heating/cooling system.

- 1) Terminal R (24 volt AC Hot Lead)
- 2) Terminal W (Heating Control)
- 3) Terminal Y (Cooling Control)
- 4) Terminal G (Manual Fan Control)

I attempted to use just those four terminals by "robbing" power from either the heating control lead (W) or the cooling control lead (Y) — the same way my existing thermostat does. Unfortunately, I discovered the 12 milliamps needed to run the PIC and associated circuitry was too high and caused the fan to run constantly when trying to draw current through the heating control lead. I then used the additional Terminal B (24 volt AC return lead) to power the PIC and its circuitry. Fortunately for me, there were extra leads going through the wall between my main heating/cooling system and my wall-mounted thermostat. This is the reason my PCB is missing the extra screw terminal needed. However, the PCB photos I provided do include all the changes needed (see the thermostat PCB LAN side template on the website and Figure 2). Please note all of the red connections on the thermostat PCB parts side layout are jumper wires. A complete schematic of the controller is shown in Figure 3.

A word of caution: Do not mistake the terminal designator letters for wire colors! The following terminal designators for heating/cooling systems are designated by NEMA (National Electrical Manufacturers Association). In 1972, the letter designators on thermostat terminals was standardized as follows:

PARTS LIST

QTY ITEM/DESC.

PART

Semiconductors

□ 1	U1/16F870 PIC	579-PIC16F870-I/SP
□ 1	U2/LM358 Op-amp	512-LM358N
□ 1	U6/LM78L05 5V Reg	512-LM78L05ACZX
□ 1	U7/LM78L15 15V Reg	512-LM78L15ACZX
□ 1	D11/15 V Zener	863-1N5352BG
□ 1	D10/50V Bridge Rectifier	833-RB151
□ 1	D12/LED 10 ma Red	606-4304H1
□ 1	U5/Optocoupler	512-MOC3033M
□ 9	D1-D9/1N914 Diode	512-1N914
□ 1	Triac/4A 200V Ig=10ma Triac	576-Q2004F31
□ 1	U4/LD34DZ Temp Sensor	ACSLM34DZ*
□ 1	U3/24x2 (Eight Data Bit) LCD	LCD1029

Hardware

□ 1	For Optocoupler/ 6 Pin DIP Socket	571-3902611
□ 1	For Op-amp/Eight Pin DIP Socket	571-3902612
□ 1	For PIC/28 Pin DIP Socket	571-3902619
□ 1	4 MHz Crystal	815-ABL-4-B2
□ 10	PB1-PB10/Pushbutton Switches	104-0010-EVX
□ 1	For Printed Circuit Board/Double Sided Copper Board	590-532
□ 2	SW1-SW2/For Fan and On/Off Sw/ DPDT Slide Switch	10SM002
□ 2	Screws for DPDT Switch	48SM006
□ 1	SW3/Heat/Cool Switch/ 4PDT Slide Switch	629-GF6426010
□ 1	BUD Plastic Box	563-CU-1945-MB
□ 1	14 Pin Socket For LCD/ 14 Pin Socket w/18" Cond	175-12140K18GA1

Resistors — Quantities are pkgs of 10 (1/8 W) (R11 was deleted)

□ 1	R13a/100Ω	299-100-RC
□ 1	R12/330Ω	299-330-RC
□ 1	R13-R14/1K	299-1K-RC
□ 7	R4-R10/10K	299-10K-RC
□ 1	R1/220K	299-220K-RC
□ 2	R2-R3/1M	299-1M-RC

10 Turn Trimpots

□ 1	Tp2/For LCD Contrast Adj/25K	72-T93YA-25K
□ 1	Tp1/For Op-amp Gain Adj/50K	72-T93YA-50K

Capacitors

□ 2	C2-C3/22 pF Ceramic	581-CK05BX220K
□ 1	C1/.22 μF Ceramic	140-50V5-224Z-RC
□ 1	C4/100 μF Electrolytic	140-L10V100-RC
□ 1	C6/10 μF Electrolytic	140-L10V10-RC
□ 1	C5/470 μF Electrolytic	140-LLRL35V470-RC

All products are from Mouser Electronics (www.mouser.com) except for the ones marked with *, which are from B.G. Micro (www.bgmicro.com).

*R or RH for heat or RC for cool (red): Hot side of transformer

*W (white): Heat control

W2 (pink or other color): Heat, second stage (in my unit, this was shown as W1 but was connected to the W terminal)

*Y or Y2 (blue or pink): Cool, second compressor stage

C or X (black): Common side of transformer (24V)

*G (green): Fan

O (orange): Energize to cool (heat pumps)

L (tan, brown, gray, or blue): Service indicator lamp

X2 (blue, brown, gray, or tan): Heat, second stage (electric)

B (blue or orange): Energize to heat

*B or X (blue, brown, or black): Common side of transformer

E (blue, pink, gray, or tan): Emergency heat relay on a heat pump

T (tan or gray): Outdoor anticipator reset

*The designators with * are used in my White-Rodgers 50A51-495 integrated hot surface ignition control unit. The thermostat controller in this article connects directly to that control unit, which is physically installed inside my heating/cooling system. Also please note the wire colors designated above may not be the same wire colors used in your system. It is necessary to match the letter designators between the control unit in the heating/cooling system and the thermostat control in this article.*

During heating season, we set the first temperature (Ts) to 68 degrees and the second temperature (T2s) to 55 degrees. The T2 start time is set to 23:30 (11:30 PM) and the T2 end time is set to 07:30 (7:30 AM) — the program default times. This results in the heat effectively being shut off between 11:30 PM and 7:30 AM, which works well for our usage. Of course, using the push-buttons on the front of the unit will

set any time period or temperature. Figure 4 shows the unit mounted on the wall. Figure 5 shows the inside of the finished unit. As with any project, this one could be improved. Some suggestions are:

- 1) Adding Saturday-Sunday weekdays to the display and including the time set functions specific to certain days of the week. Note: Since I am retired, I didn't worry about implementing Days of the week programming — mea culpa.
- 2) Making the unit smaller by using a smaller LCD display and more programming to enable it to display two or more separate screens with different information.
- 3) Shorter and more efficient programming to implement the above improvements.

I welcome any comments, advice, or suggestions from readers to improve this project. I would also be happy to further discuss any aspect of this project and am also willing to program the 16F870 PIC if it is sent to me in a SASE with suitable packing to protect it. No charge! You may contact me at chuckirwin43@gmail.com for my mailing address and/or any other help or advice you need. I hope you all enjoy this project as much as I did. **NV**



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How to create a podcast

Podcasting allows listeners to receive audio programs via a subscription through the Internet and listen to them at their leisure on a portable music player (MP3 player) or computer.

The term podcasting is a combination of "iPod" + "broadcasting;" however, you don't need an iPod specifically to listen to podcasts. Any MP3 player is convenient because they allow you to listen to audio content on the go. Some people prefer listening to podcasts while working at their computer. "Vodcasting" works the same way as podcasting, but also incorporates video.

The process of creating a podcast includes the following steps:

- 1) Recording (or choosing) files for the podcast. Most often, it is audio files recorded with a microphone or a special recording tool and saved in the MP3 format.
- 2) Creating an RSS feed where each item contains a link to its enclosure file.
- 3) Uploading the feed and enclosure files to the specific server and creating a link to the RSS feed on website pages.

A usual podcast differs from an RSS feed because it has enclosures that can be either audio or video files. If an RSS feed uses iTunes extensions, for example, the corresponding fields must be filled for every enclosure (descriptions, keywords, duration). Of course, after you create a podcast, the RSS feed and enclosure files should be uploaded to the web server for podcast listeners to be able to access them.

To create such an RSS feed, you can use special software that will allow you to create a podcast as quickly as possible and help you avoid errors. Some of these are:

- Feed Editor (www.extralabs.net/feed-editor.htm) — A program for creating, editing, and publishing podcasts.
- Audacity (www.audacity.sourceforge.net/) — Record your voice from a microphone.
- Podcast Wizard (www.extralabs.net/podcast-wizard.htm) — Step-by-step podcast creation.
- LemonzDream (www.lemonzdream.com/) — Podcast creator for Macs.

How to Promote a Podcast

Recording, editing, and uploading a podcast is simply not enough to get it heard. Attracting listeners will take promotional techniques and a bit of imagination, especially if you'd like your site 'hit' counter to increase considerably.

- Submit your content to specialized podcast directories.
- Send the URL of your podcast to major search engines.
- Seek out forums on subjects similar to your podcast and join in on the conversation.
- Contact the webmasters of sites of your subject matter and offer to exchange links.

Podcast From Wikipedia: A podcast is a collection of digital media files which is distributed over the Internet, often using syndication feeds, for playback on portable media players and personal computers. The term podcast, like "radio," can refer either to the content itself or to the method by which it is syndicated; the latter is also termed podcasting. The host or author of a podcast is often called a podcaster.

In the March '07 issue of *Nuts & Volts*, there's a complete article on podcasting by Ed Driscoll. Also, if you do an article search on podcasting and MP3, there's plenty of other good info in previous issues. Just go to www.nutsvolts.com.

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The Weather Channel

New Weather Mapplet for Google Maps; Provides Weather Data Layer for Google Earth

The Weather Channel Interactive, Inc. (TWCI), has a new mapplet for Google Maps, making weather conditions available on the map with one click. In addition, TWCI has been selected as the weather provider supplying current weather conditions, forecasts, and radar in Google Earth.

The weather data layer on Google Maps and Earth features current conditions powered by HiRAD (High Resolution Aggregated Data), which is an exclusive patented technology developed by The Weather Channel that delivers a more local snapshot of current weather

conditions for the contiguous United States. HiRAD combines traditional weather observations with data obtained by Doppler radar, satellite, lightning strike detection, computer models, and climate profiles to provide unique conditions for 1.9 million locations.

The weather mapplet for Google Maps enables users to add customizable weather layers to their map. Options include clouds and radar and points of interest, such as US and international cities, and airports and US golf courses, lakes, and schools. When selected, a bubble will appear at the point on the map with current weather conditions and temperature displayed. If there is severe weather for a point of interest, the bubble will be displayed in red with details of the alert.

The mapplet's weather bubbles expand with a click to display HiRAD data for the point of interest including

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outlooks on **weather.com**. Also available are radar images on the map which are provided by **weather.com** and Weather Services International (WSI) via a product known as NOWrad.

Meet The Weather Channel Interactive

The Weather Channel Interactive reaches more than 35 million unique users online each month and is the most popular source of online weather, news, and information according to Nielsen//NetRatings. It also provides consumers with unique and customizable products such as Desktop Weather and a full lineup of mobile services including downloads, messaging, mobile Web, and mobile video. (What projects are you working on that would have more of a "cool factor" if you incorporated real-time weather data?)



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TIME

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by **Norm Looper**
Chief Engineer,
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*A Nuts & Volts Designer's Guide to
reliable oscillators and timers.*

**“If you’re not
confused when you
start, you’re not
doing it right.”**

– Richard Feynman, Nobel Laureate

PART 2 :

Understanding And Designing With The Ever-Useful CMOS Timer

Not as commonplace as the operational amplifier, the integrated circuit CMOS timer — such as the ICM7555 and TLC555 — has nonetheless found a secure niche in electronics. Why is this?

Like most successful standard forms, timers solve several problems at once. In this case, these problems include threshold definition, charging and discharging of an RC (resistor/capacitor) tank, and generating a precision output pulse. With these capabilities, a wide variety of oscillators and timing circuits can be realized. Further flexibility is provided by a wide range of supply voltages: from 2 volts to 15 volts.

These timers are second-generation CMOS versions of the original NE555 bipolar timer, and they have the same pin-out as the original. In most cases, they are pin-for-pin compatible with their progenitor, but they feature greatly reduced power consumption and input bias currents in addition to higher speed. Quiescent power consumption is less than 2 mW.

A familiar assumption made by many designers is that a timer in their microprocessor circuits is not needed, since the microprocessor itself can be programmed to perform timing functions. However, this conviction is often

reversed when they observe a long period timing task tie up their microprocessor and they see how complicated sampling and interrupt structures can become in achieving long intervals.

A chaste design philosophy is to hand-off a long timing interval to a precision, inexpensive timer by triggering it with a brief downward pulse from one of the processor's output pins. The microprocessor is then free to go its way, and can check the state of the timer's output pulse at any convenient time later. The execution speed of the processor is thus preserved and the code is made more transparent.

Describing the Timer

As shown in Figure 1, an integrated timer circuit combines an analog window comparator with digital logic for sequencing the charging and discharging of an RC tank circuit whose voltages are captured within the defined window. A resistive divider of three silicon pinch resistors, each with a value of approximately 80K, defines the window by biasing two precision comparators at $V_{cc}/3$ and $2V_{cc}/3$, respectively. The control pin CON, pin 5, brings

out the upper divider voltage.

Comparator A's positive input is brought out on the threshold THR, pin 6, and comparator B's negative input is brought out as the trigger TRG, pin 2. The comparator outputs are fed into digital logic in the form of an RS flip-flop that remembers the comparator's output transitions. Bias currents on these inputs are quite small; on the order of nanoamperes (nA).

A discharge MOSFET DIS, pin 7, is also provided to rapidly discharge the capacitor in the tank circuit. The drain of this FET is reverse biased by a diode attached to Vcc to prevent people from using the open drain with a pull-up resistor to a voltage greater than Vcc. The enable input EN, pin 4, when taken low (i.e., 0 volts) resets the flip-flop and locks the timer output VO, pin 3, low, (i.e., 0 volts). EN, also called "reset" or "not reset" is seldom used, but has some special uses as discussed herein.

The Timer as a One-Shot

Take a look at Figure 2. The monostable or "one-shot" connection of the timer enables the flexible generation of single pulses of durations ranging from about one microsecond to one second. At first glance, this capability might seem of questionable value, since the user is required to generate a triggering pulse of duration somewhat less than the output pulse itself. Considering however that the output pulse is a clean square wave that can be made stable with variations in temperature and rail voltage, the advantages become more apparent. Further, the pulse duration is easily tailored by selection of the RC tank, and the output, Vo, has a considerable ability to source and sink reasonable loads. Sourcing is at least 10 mA and sinking currents range upward to 100 mA.

In this form only, note that alternatively, R can be connected to Vcc instead of Vo, with Vo being entirely free except for external loads. This is an older connection form that is a remnant of when timers were fabricated with bipolar technology.

Figure 2 shows the connections necessary for monostable operation. Here, the threshold and trigger inputs are separated, with a negative-going pulse on the trigger being the initiating stimulus. Input THR (threshold, pin 6) is still attached to the capacitor, and DIS is attached to C also. The

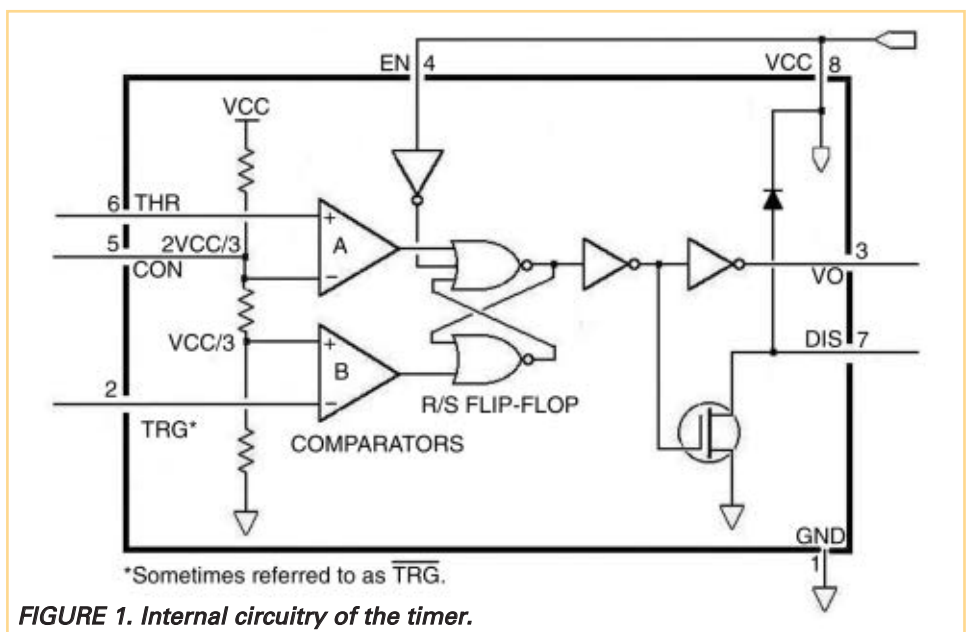


FIGURE 1. Internal circuitry of the timer.

essential triggering rule specifies that the triggering waveform (pin 2) must recover above the *lower threshold* of $V_{cc}/3$ before the capacitor in the RC tank achieves the "time-out" threshold voltage of $2V_{cc}/3$ – and since the output pulse is high while the capacitor is charging from 0 volts to $2V_{cc}/3$, a little mathematics shows that the output pulse duration, Tcharge, is given by:

$$T_{\text{charge}} = 1.1 \times R \times C$$

Example: We want to generate an output pulse of one millisecond duration, and accordingly choose $R = 90.9K$, and $C = .01 \mu F$, producing a nominal pulse of one millisecond $\pm 10\%$.

$$T_{\text{charge}} = 1.1 \times R \times C = 1.1 \times (90.9 \times 10^3) \times (1 \times 10^{-8}) = 1 \times 10^{-3} \text{ seconds}$$

When Tcharge ends, the internal MOSFET servicing DIS rapidly discharges the capacitor and prepares the timer for another triggering pulse. Since the "on-resistance," Ron, of the MOSFET is specified at

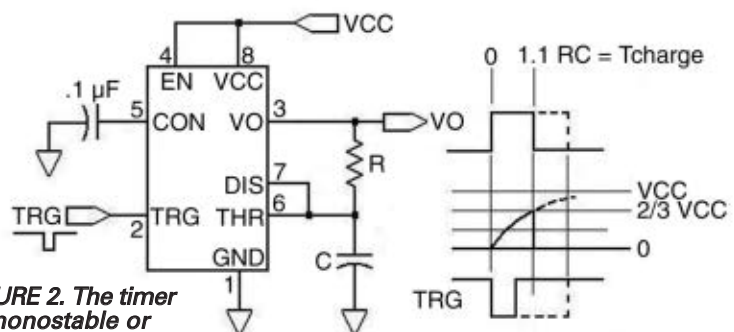


FIGURE 2. The timer in monostable or "one-shot" mode.

40 ohms maximum, we should allow some recovery time, T_{recover} , to drain the capacitor before retriggering.

$$T_{\text{recover}} = 4 \times 40 \text{ ohms} \times C$$

Using this formula, we should allow 1.6 microseconds for a capacitor value of .01 μF , before re-triggering the timer.

Triggering Rules

Many of the problems encountered by beginning timer users are related to triggering. As shown in Figures 1 and 2, the timed output V_o is made to go high when the voltage on the /TRG (read as “not trigger”) is taken below $V_{\text{cc}}/3$. This causes the lower comparator to transition to a logic 1 (high), which sets the RS flip-flop. The capacitor starts charging at ground, having been discharged and clamped there by the internal MOSFET accessible as DIS on pin 7.

The change in the output state of the flip-flop turns off the MOSFET, and V_o begins to charge capacitor C through resistor R . The numerical product, RC , is the time constant that applies to this charging, and the capacitor voltage rises in a diminishing exponential curve. This voltage passes upward through the lower threshold without changing the state of the flip-flop until it reaches the higher threshold of $2V_{\text{cc}}/3$. This charging occupies 1.1 time constants (i.e., $1.1RC$) of the tank circuit and determines the duration of the V_o output pulse, T_{charge} .

Looking at the internal logic, we can see that the /TRG waveform must return to its normal high level before the capacitor reaches the upper threshold – otherwise, as shown by the dashed lines at the V_o and /TRG waveforms, output V_o will “hang” and not transition to low. This is the basis for the previously cited triggering rule. Thus, the pulse width of /TRG from the initiating

processor or other logic must be kept reliably less than the desired output pulse width.

Note that the upper node of the divider is brought out on the control pin. This pin is seldom used, even by seasoned designers. Strictly speaking, CMOS timers do not require a decoupling capacitor attached to CON, but I never miss an opportunity to decouple DC networks, and I recommend .1 μF as shown to achieve additional filtering of V_{cc} .

Generating the Trigger Pulse in the One-Shot Mode

Figure 3 shows two ways of generating a triggering pulse for monostable operation. The first (“often used”) employs an RC trigger network (R_{tr} and C_{tr}) with a recovery clamp diode to generate a pulse from the falling edge of a square pulse. This method incorporates the liability of all differentiating networks – sensitivity to outside noise, conducted or radiated into the circuit by infrequent, spurious events. This can produce unwanted triggering. On the other hand, it generally does not require extra logic gates to implement. Notice the small positive spike when V_{in} rises and the clamp comes on.

The triggering waveform recovers upward to $V_{\text{cc}}/3$ in a time given by $.4 \times R_{\text{tr}} \times C_{\text{tr}}$. Thus, to conform to our triggering rule, we must keep the recovery time less than $1.1 \times R \times C$ of the tank circuit.

$$\text{Keep } R_{\text{tr}} \times C_{\text{tr}} < (1.1 / .4) \times R \times C, \text{ or} \\ R_{\text{tr}} \times C_{\text{tr}} < 2.75 \times R \times C, \text{ so that}$$

$R_{\text{tr}}C_{\text{tr}} < RC$ is a safe rule, and allows generous component tolerances.

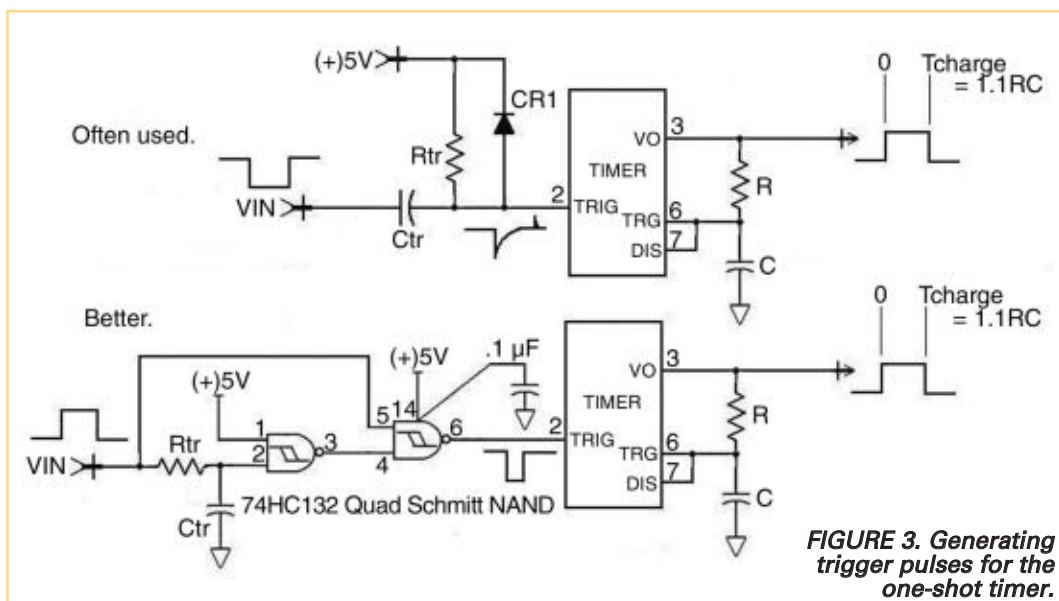


FIGURE 3. Generating trigger pulses for the one-shot timer.

The second method (see “better”) generates the trigger pulse using an integrating network. This method is more likely to be used by careful designers; it works well and has inherent noise rejection. Two Schmitt NAND gates generate a trigger pulse from the delay in the charging of C_{tr} , by currents through R_{tr} . Besides establishing the trigger’s pulse width, the R_{tr} and C_{tr} combination acts as a low-pass filter that rejects spurious noise. The “safe” triggering time constant for this method differs

from the “often used” form: There is much less margin. So a reasonable rule that allows for component tolerances requires:

Keep $R_{tr}C_{tr} < .4 RC$.

The Timer as a Free-Running Oscillator

The timer in free running (or astable) mode becomes a digital oscillator. In Figure 4, we see that the threshold (pin 6) and trigger (pin 2) inputs have been externally connected to form a single input into both comparators. The output V_o performs double duty by alternately charging and discharging C through R . Since the voltage on C is connected to the trigger and threshold inputs and responded to by the comparators, the feedback loop is thereby closed, and oscillation is sustained. Take a little time to reason your way through how the logic responds to the comparators to generate the output V_o .

The exponential charging and discharging waveform of the capacitor is, of course, trapped between the trigger and threshold pins, and the total time required to alternately charge and discharge the capacitor defines the period of oscillation – the reciprocal of which is the frequency. As shown in Figure 4, the charging and discharging of the capacitor within the threshold window consumes 7/10 of a time constant of the RC network. And since both operations determine the period (T_{period}) of oscillation, we have:

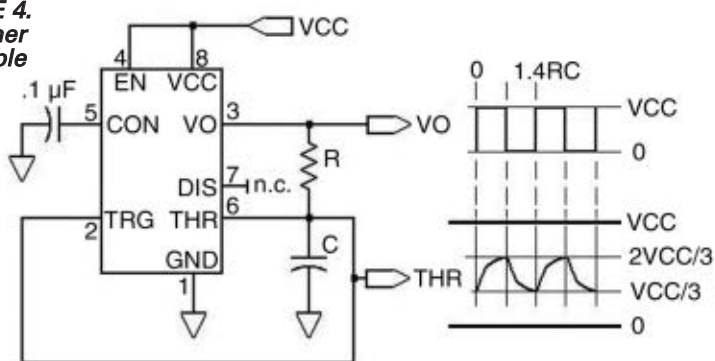
$$T_{period} = T_{charge} + T_{discharge} = (.7 \times R \times C) + (.7 \times R \times C) = 2 \times (.7 \times R \times C) = 1.4 RC$$

$$\text{and the frequency} = 1 / T_{period} = 1 / 1.4RC$$

Using our previous values of $R = 90.9K$ ohms and $C = .01 \mu F$, we arrive at $T_{charge} = T_{discharge} = .636$ milliseconds and $T_{period} = 1.27$ milliseconds.

Frequencies from about 1 Hz to 1 MHz can be reliably produced in this mode. The lower limit is set by the capacitor leakage current relative to the charging current. The careful designer will resist the temptation to realize frequencies below about 1 Hz (i.e., periods greater than one second) directly from the timer by employing large values of R and C . Rather, one should apply some kind of “divide-by-N” counter to V_o or a series of flip-flops to achieve longer periods. Otherwise, instability with temperature and time relating to the RC tank circuit will

FIGURE 4.
The timer in astable mode.



usually plague what at first looks to be a good result. Capacitors above one microfarad will typically be tantalum or aluminum electrolytic selections with leakage many times greater than film capacitors at one microfarad or below.

With the above in mind, the following approximate limits on R and C will prove to be helpful.

$$5K \text{ ohms} \leq R \leq 2 \text{ megohms}$$

Use a 1% tolerance metal film resistor, leaded or SM, 100 ppm/C or less.

$$20 \text{ picoFarads} \leq C \leq 1 \text{ microFarad}$$

Tolerance 5%, film, use polymer, X7R or NPO dielectric.

For $C > 1 \mu F$, compute the capacitor’s leakage at V_{cc} and compare it to the minimum charging current. When selecting a tantalum or aluminum electrolytic capacitor, you can minimize this leakage by choosing a unit with a substantially higher working voltage than V_{cc} . I often use capacitors with a rating of 35 VDC working voltage.

The upper limit on frequency is set by the speed of the integrated circuit itself. This is specified at 1 MHz in the astable mode. But in the one-shot mode, note that $T_{recover}$ (the recovery time) limits the pulse repetition rate.

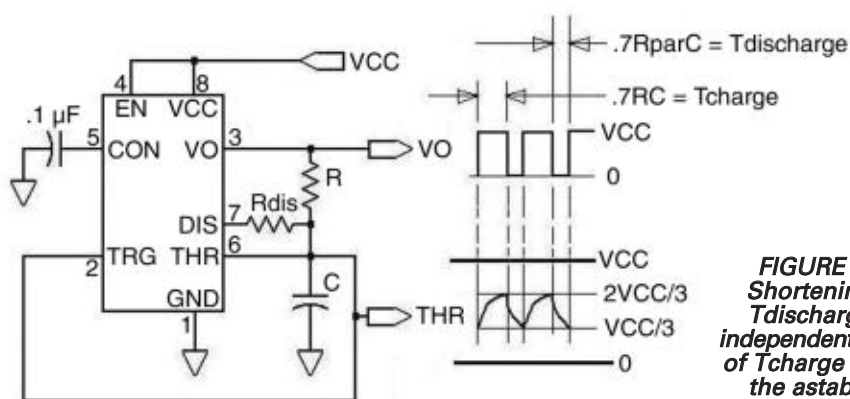


FIGURE 5.
Shortening Tdischarge independently of Tcharge in the astable mode.

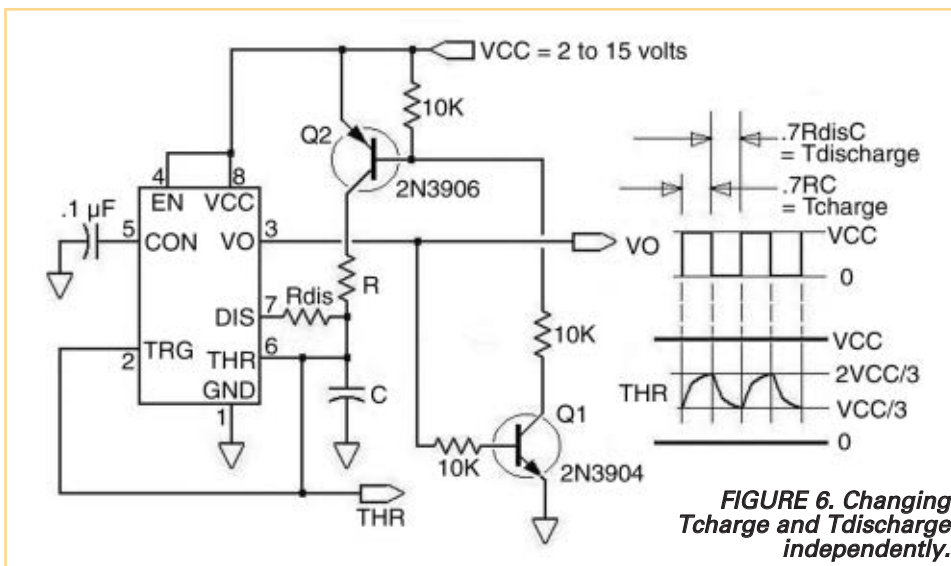


FIGURE 6. Changing Tcharge and Tdischarge independently.

Varying the Duty Cycle of the Astable Oscillator

Look at Figure 5. A variation on the RC tank circuit enables the user to set the duty cycle greater than 1/2 for the astable timer. Here, we shorten the discharge time by the addition of resistor Rdischarge. The astute reader will note that *charging* occurs solely through R, while *discharging* occurs *both* through R and Rdischarge. Thus:

$$T_{\text{period}} = T_{\text{charge}} + T_{\text{discharge}} = .7RC + .7R_{\text{par}}C$$

where Rpar is the parallel combination of R and Rdis, derived as:

$$R_{\text{par}} = (R \times R_{\text{dis}}) / (R + R_{\text{dis}})$$

Again, continuing our example with the previous values, let's shorten Tdischarge to .32 milliseconds. To do this, choose Rdischarge = 90.9K.

$$T_{\text{charge}} = .7RC = .636 \text{ milliseconds (as before)}$$

$$R_{\text{par}} = (90.9 \times 10^3)(90.9 \times 10^3) / (90.9 \times 10^3 + 90.9 \times 10^3) = 45.45 \times 10^3 \text{ ohms. Choose the nearest MIL decade value of 45.3K ohms.}$$

$$T_{\text{discharge}} = .7 \times 45.3 \times 10^3 \times 1 \times 10^{-8} = .317 \text{ milliseconds}$$

$$T_{\text{period}} = .636 \text{ milliseconds} + .317 \text{ milliseconds} = .953 \text{ milliseconds}$$

$$\text{Frequency} = 1 / T_{\text{period}} = 1.05 \text{ kHz}$$

$$\text{Duty cycle, } d, \text{ is defined as } = T_{\text{charge}} / T_{\text{period}} = .67$$

Changing Tcharge and Tdischarge Independently of Each Other

This is more involved. Figure 6 shows a method for this that requires some extra transistors, but does not degrade the temperature stability of the circuit, as popular diode approaches definitely do.

Here we have Vo drive two saturated switches Q1 and Q2. Q2 connects Vcc to tank resistor R only during the charge time when Vo is high, and the discharge FET at DIS, pin 7, is off. No current flows through Rdis during Tcharge. During the discharge time, no current flows through R, but only through Rdis. This makes

Tolerances on Frequency

One of the strengths of the timer is that the duration of the output pulse, Tout, is largely invariant with typical changes in Vcc because the timing is determined by the fixed ratio of the upper and lower threshold resistors which are, in turn, driven by Vcc. Interestingly, this invariance is true, even though the charging is nonlinear, because the charge scaling is completely maintained.

However, diffusion processes for the internal resistors limit fabrication of the resistor ratios to about $\pm 2\%$ accuracy. I allow a total of $\pm 5\%$ inherent timer accuracy. Also, allowing for component tolerances as previously recommended, we arrive at a probable error of $\pm 7.1\%$ RSS (root-sum-square) and a maximum timing error within $\pm 11\%$.

Temperature stability of the timer input is typically within $\pm 100 \text{ ppm/C}$. Allow another 1% timing error for aging during the first 1,000 hours of use, after which the unit should be essentially stable.

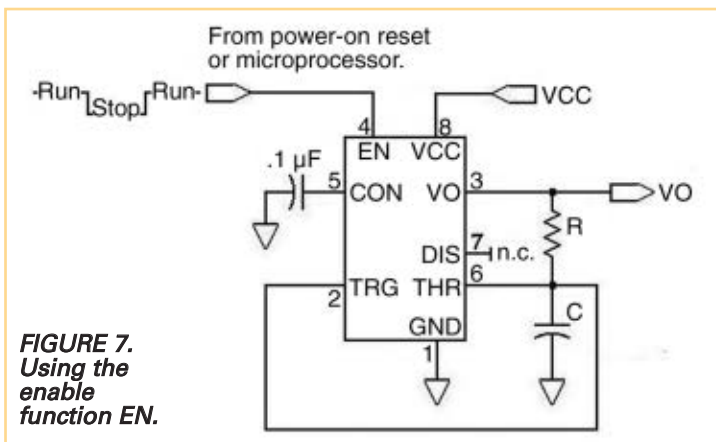


FIGURE 7. Using the enable function EN.

Tcharge and Tdischarge independent of each other.

Using the ENABLE Function

As shown in Figure 7, EN, pin 4, when taken low, forces Vo low by resetting the RS flip-flop. This does not appreciably reduce the timer's quiescent power, but prevents TRG and THR from functioning.

EN in the one-shot mode can be used to terminate a pulse in progress, but is otherwise not particularly useful since the timer remains inactive unless triggered anyway. In the asynchronous mode, EN can be used by a microprocessor to initiate or terminate oscillation, but note that the initial Tcharge time will be longer ($= 1.1 RC$) than any succeeding charge times ($= .7RC$) because the capacitor starts at zero volts, but later is trapped between $V_{cc}/3$ and $2V_{cc}/3$.

EN is often used as a power-on reset, being held low by a special reset circuit when power is first applied, and remaining there until all circuitry (including the microprocessor) is live and settled. There are other techniques for using EN, but these will not be covered here. Check out manufacturer's application notes.

Conclusion

In the various figures, no output logic buffers have been shown for Vo for simplicity. Isolating Vo by buffering is always a sound procedure and I recommend it. This insures that small variations in Vo due to variable external loads do not affect the tank charge or discharge times.

Finally, remember to observe all precautions to avoid electrostatic damage when storing and installing the part. CMOS static damage is often latent, showing up only weeks

after the damaging shock has occurred. However, once the timer is soldered safely into the circuit, it is difficult for it to experience electrostatic damage because of distributed circuit capacity.

I suggest that you keep several timers such as the TLC555 on hand. You never know when you might need a tailored square wave or pulse in your design — and your microprocessor will thank you for the outside help! **NV**

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The author welcomes reader comments and can be reached at chiefengineer1284@analogscientific.net.

By Jan Axelson ACCESS SERIAL PORTS WITH VISUAL BASIC .NET

If you have a microcontroller circuit that needs to talk to a PC, a serial port can do the job. Serial ports can transfer data for just about any purpose. For example, a microcontroller can send sensor data for a PC to analyze and display. Or, a PC can send commands to control robots or other devices.



No serial port on your PC? No problem! To add a serial port, attach a USB/serial adapter to a USB port. This article focuses on the PC side of serial port communications. I'll show how to use Visual Basic .NET to access serial ports, including USB virtual serial ports.

Serial Ports and COM Ports

A serial port is a computer interface that transmits bits one at a time. The interface can have as few as three lines: one to carry data in each direction plus a ground line. Many interfaces have up to six additional lines to carry status and control information.

Unlike some serial interfaces, the standard RS-232 serial interface on PCs doesn't include a clock line. Instead, the computers at both ends of the cable each provide a clock. The computers must agree on a bit rate for transferring data, and a Start bit synchronizes the clocks before each transmitted byte.

RS-232 is a hardware interface that transmits 0s and 1s as positive and negative voltages. A typical RS-232 cable can be up to 100 ft long. Interface chips such as Maxim's MAX232 converts between 5V logic and RS-232 voltages.

On a PC, serial ports appear as numbered COM ports that applications can read and write to. These days, most standard peripherals connect via USB, and many PCs don't have built-in serial ports. You can add an RS-232 port to any recent PC, however, by attaching a USB/RS-232 adapter module. Your favorite PC hardware vendor likely has a selection to choose from.

For each adapter, Windows creates a USB virtual COM port that applications can access just like built-in serial ports. If you don't want to use an external adapter, you can perform the conversion inside the device by adding a USB/serial bridge chip to your design. FTDI's FT232R is an example of a bridge chip.

Selecting a Port

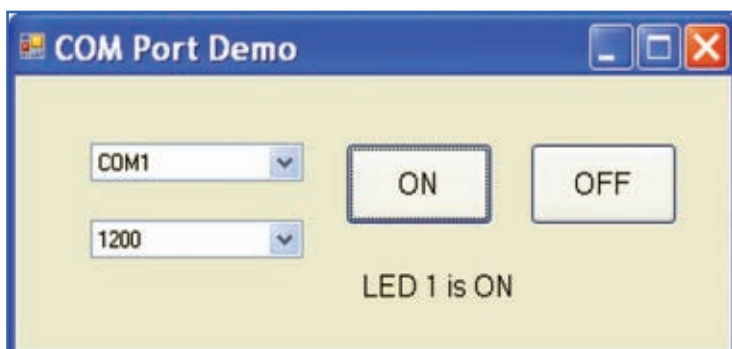
Figure 1 shows a Windows form for an application that uses a serial port to control an LED on a remote device. (The full Visual Basic project is available from www.nutsvolts.com and my website, www.Lvr.com.)

Combo boxes enable selecting a COM port and bit rate. Clicking the ON or OFF button sends a command to turn an LED on the remote device on or off. A label displays a message about the state of the LED as reported by the device.

This example can serve as a framework for developing applications that monitor and control other external devices.

Microsoft's Visual Basic .NET, including the free Express edition, includes a SerialPort class for accessing COM ports. Other .NET languages such as Visual C# can use the class, as well.

FIGURE 1. Clicking a button sends a command and displays a response.



In applications that use the `SerialPort` class, include an `Imports` statement to avoid having to specify the namespace each time you use a class member. Place the statement at the top of the file, preceding the `Module` or `Class` statement and following any `Option` statements:

```
Imports System.IO.Ports
```

Before you can access a port, you need to create a `SerialPort` object. This statement creates a `SerialPort` object called `myComPort`:

```
Dim myComPort As New SerialPort
```

Listing 1 shows a routine that finds COM ports on the system and sets a default port and other parameters. To run the routine when the application starts, call the routine in the `Form_Load` event.

The `SerialPort` class's `GetPortNames` method returns an array of the names of all of the PC's COM ports. The array's elements aren't guaranteed to be in alphabetical order, but the `Array.Sort` method can sort the names if needed. The `SelectedIndex` property sets the default COM port.

The `cmbPorts` combo box displays the COM ports. The `cmbBitRate` combo box lists the supported bit rates. The `SelectedItem` property sets the default bit rate.

Accessing a Port

The `OpenComPort` routine (Listing 2) sets port parameters and attempts to open the selected port. The routine sets `myComPort`'s `PortName` and `BaudRate` properties to match the selections in the combo boxes. (For the purposes of this discussion, the bit rate and baud rate are the same thing.)

For other properties such as the number of data bits and parity type, the routine sets values. To enable users to change these properties, you can add combo boxes that offer options for these properties.

The `ReadTimeout` and `WriteTimeout` values set the number of milliseconds the application will wait when attempting to read or write to the port. For read operations, the timeout sets how long the application will wait for data after calling a read method. For write operations, the timeout sets how long the application will wait to finish a write operation. Flow-control methods can delay writing to a port if the receiving computer isn't ready to accept data.

Before reading or writing to a port, the application must open a connection to the port. The `Open` method opens a connection to the port named in the `PortName` property. If the selected port doesn't exist, is already open, or can't be opened for another reason, a message

box appears describing the problem.

The `CloseComPort` routine (Listing 3) closes an open port and releases its resources. The form's `FormClosing` event can call this routine to close the port when the application ends. The routine waits for any transmitting bytes to finish transmitting or a timeout. The `Using` block's `End Using` statement closes `myComPort` and disposes of its resources.

Closing a port can take up to a few seconds, so applications and users should delay a bit between closing a port and re-opening the same one.

When a user selects a new COM port in the `cmbPorts` combo box, the combo box's `SelectedIndexChanged` event executes. Placing this code in the event's routine closes the previously selected COM port if needed, sets `myComPort`'s `PortName`

```
Sub InitializeForm()
```

```
Dim bitRates(9) As Integer
Dim nameArray() As String
```

```
` Find the COM ports on the system.
```

```
nameArray = SerialPort.GetPortNames
Array.Sort(nameArray)
```

```
` Fill a combo box with the port names.
```

```
cmbPorts.DataSource = nameArray
cmbPorts.DropDownStyle = _
    ComboBoxStyle.DropDownList
```

```
` Select a default port.
```

```
cmbPorts.SelectedIndex = 1
```

```
`Bit rates to select from.
```

```
bitRates(0) = 300
bitRates(1) = 600
bitRates(2) = 1200
bitRates(3) = 2400
bitRates(4) = 9600
bitRates(5) = 14400
bitRates(6) = 19200
bitRates(7) = 38400
bitRates(8) = 57600
bitRates(9) = 115200
```

```
`Place the bit rates in a combo box.
```

```
cmbBitRate.DataSource = bitRates
cmbBitRate.DropDownStyle = _
    ComboBoxStyle.DropDownList
```

```
` Select a default bit rate.
```

```
cmbBitRate.SelectedItem = 1200
```

```
End Sub
```

LISTING 1. Combo boxes on the form enable users to select a port and bit rate.

```

Sub OpenComPort ()

    Try

        ' Get the selected COM port's name
        ' from the combo box.

        If Not myComPort.IsOpen Then
            myComPort.PortName = _
                cmbPorts.SelectedItem.ToString

            ' Get the selected bit rate from the combo
box.

            If cmbBitRate.SelectedIndex > 0 Then
                myComPort.BaudRate = _
                    CInt (cmbBitRate.SelectedItem)
            End If

            ' Set other port parameters.

            myComPort.Parity = Parity.None
            myComPort.DataBits = 8
            myComPort.StopBits = StopBits.One
            myComPort.Handshake = Handshake.None

            myComPort.ReadTimeout = 3000
            myComPort.WriteTimeout = 5000

            ' Open the port.

            myComPort.Open()

        End If

        Catch ex As InvalidOperationException
            MessageBox.Show(ex.Message)

        Catch ex As UnauthorizedAccessException
            MessageBox.Show(ex.Message)

        Catch ex As System.IO.IOException
            MessageBox.Show(ex.Message)

    End Try

End Sub

```

LISTING 2. Before transferring data, the application must set port parameters and open a connection to the port.

```

Sub CloseComPort ()

    Using myComPort

        If (Not (myComPort Is Nothing)) Then

            ' The COM port exists.

            If myComPort.IsOpen Then

                ' Wait for the transmit buffer to empty.

                Do While (myComPort.BytesToWrite > 0)
                    Loop

            End If

        End If

    End Using

End Sub

```

LISTING 3. The End Using statement closes the port and disposes of its resources.

property to match the new selected port, and opens the selected port:

```

CloseComPort ()
myComPort.PortName = _
    cmbPorts.SelectedItem.ToString
OpenComPort ()

```

When a user selects a new bit rate in the cmbBitRate combo box, the combo box's SelectedIndexChanged event executes. Placing this code in the event's routine sets myComPort's BaudRate property to match the selected bit rate:

```

myComPort.BaudRate = _
    CInt (cmbBitRate.SelectedItem)

```

Each button on the form has a click event, which calls the SendCommand routine to send a command to the COM port. Place this code in the ON button's click event to send the command "L11":

```
SendCommand("L11")
```

The first two bytes ("L1") identify LED 1 on the device. The third byte "1" tells the device to turn on LED 1.

Place this code in the OFF button's click event to send "L10" to tell the device to turn off LED 1:

```
SendCommand("L10")
```

Listing 4 is the SendCommand routine. The WriteLine method writes the command and a line-feed (LF) code (0Ah) to the port. Using the SerialPort class's default encoding, each text character transmits as an eight-bit ASCII code.

The application waits to receive a response that ends with an LF. On receiving a response, a label on the form (lblStatus) displays a message. If the device doesn't respond after the number of milliseconds in ReadTimeout, a message box displays an error message.

You can request other actions from the remote device by modifying or adding to the commands and responses. To automate the communications, a Timer component's Tick event can send commands at intervals.

Detecting Received Data

In the example application, the device sends data only when the PC application requests it. If your device sends data at unpredictable times, the DataReceived event can detect data when it arrives.

Listing 5 shows how to use the event to retrieve data. The `SerialPort` class's `DataReceived` code runs in a different program thread. For this reason, if you retrieve received data in a `DataReceived` event and want to display the data on the application's form, you need to define a delegate to pass the data to the form. For an example of how to do so, see the `ComPortTerminal` example at www.Lvr.com.

Another way to detect received data is to use a `Timer` component to check for new data at intervals.

More on Transferring Text

The example application sends and receives data — including numbers — as codes that represent text characters. For example, to send “1,” the port transmits the byte 31h (00110001), which is the ASCII code for the character 1. To send “111,” the port transmits 31h three times; once for each character in the number.

Treating data as text is the obvious choice for transferring strings or files that contain text. To transfer numeric values, one option is to send the bytes as text in ASCII hex format.

Any byte value can be expressed as a pair of hexadecimal (base 16) characters where the letters A–F represent values from 10 to 15.

For example, consider the decimal number 225. Expressed as a binary value, it's $(2^7) + (2^6) + (2^5) + (2^0)$, or: 11100001. In hexadecimal, it's E1. The ASCII codes for the characters “E” and “1” expressed in hexadecimal are: 45 31. So the binary representation of E1h in ASCII hex consists of these two bytes: 01000101 00110001.

A serial link using ASCII hex format sends the decimal value 225 by transmitting the two bytes above. A computer that receives ASCII hex values can convert the characters to numeric values or use the data as-is.

An advantage to ASCII hex is being able to represent any byte value using just 16 ASCII codes. The values 30h–39h represent the characters 0–9, and 41h–46h represent the characters A–F. Code that allows lower-case letters uses 61h–66h to represent a–f.

All of the other values are available for alternate uses, such as software flow-control codes or an end-of-file indicator. Because the ASCII hex codes are all less than 80h, a serial link transmitting these values can save a little time by ignoring the high bit and transmitting seven-bit values.

Listing 6 shows Visual Basic functions for converting between binary values and ASCII hex strings.

Listing 4 used `WriteLine` and `ReadLine` to exchange data. The `SerialPort` class provides several other options

for reading and writing text. To send a string without appending an LF, use the `Write` method. The `Write` method can also write a `Char` array to a port. The

```
Private Sub SendCommand(ByVal command As String)

    Dim response As String

    Try

        myComPort.WriteLine(command)
        response = myComPort.ReadLine

        Select Case response

            Case "0"
                lblStatus.Text = "LED 1 is OFF"

            Case "1"
                lblStatus.Text = "LED 1 is ON"

            Case Else

        End Select

        Catch ex As TimeoutException
            MessageBox.Show(ex.Message)

        Catch ex As InvalidOperationException
            MessageBox.Show(ex.Message)

        Catch ex As UnauthorizedAccessException
            MessageBox.Show(ex.Message)

    End Try

End Sub
```

LISTING 4. The `SendCommand` routine sends a text command to the COM port and waits for a response.

```
` Define the event handler for received data.

Private SerialDataReceivedEventHandler1 _
    As New SerialDataReceivedEventHandler _
    (AddressOf DataReceived)

` Specify the routine that runs when
` a DataReceived event occurs at myComPort.

AddHandler myComPort.DataReceived, _
    SerialDataReceivedEventHandler1

` This routine runs when data arrives at myComPort.

Friend Sub DataReceived(ByVal sender As Object, _
    ByVal e As SerialDataReceivedEventArgs)

    Dim newReceivedData As String

    ` Get data from the COM port.

    newReceivedData = myComPort.ReadExisting

    Console.WriteLine(newReceivedData)

End Sub
```

LISTING 5. The `DataReceived` event can detect and retrieve received data.

```

Private Function ConvertAsciiHexToByte _
    (ByVal asciiHexToConvert As String) As Byte

    Dim convertedValue As Byte

    convertedValue = Convert.ToByte(asciiHexToConvert, 16)
    Return convertedValue

End Function

Private Function ConvertByteToAsciiHex _
    (ByVal byteToConvert As Byte) As String

    Dim convertedValue As String

    convertedValue = Hex$(byteToConvert)
    Return convertedValue

End Function

```

LISTING 6. These functions convert between byte values and ASCII hex strings that represent the bytes.

ReadExisting method in Listing 5 returns immediately with everything in the receive buffer or an empty string if the buffer is empty. The ReadTo method is like ReadLine but enables defining any character as the delimiter. The Read method copies received characters into a Char array.

If those options aren't enough, you can use the SerialPort object's BaseStream property to obtain a Stream object for transferring text data. For more on any of these methods, see .NET's Help.

Transferring Binary Data

A disadvantage of using ASCII for numeric data is that each byte value uses two characters, so data takes twice as long to transfer. Also, in most cases the application at each end must convert between hex and binary.

With binary data, values aren't converted to text characters. The decimal value 1 transmits as 00000001 rather than as the ASCII code for the character "1." With binary data, any value from 0 to 255 can transmit as a single byte. When sending or receiving binary data, the SerialPort object assumes nothing about what the values mean.

A way to transmit binary data is to place the bytes in an array. This example creates a three-byte array and writes the array's contents to a port:

```

Dim byteBuffer(2) As Byte

byteBuffer(0) = 85
byteBuffer(1) = 83
byteBuffer(2) = 66

myComPort.Write(byteBuffer, 0, 3)

```

Sources

*Future Technology Devices International
Limited (FTDI)*

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www.ftdichip.com

Maxim Integrated Products

RS-232 and RS-485 interface chips

www.maxim-ic.com

Microsoft

Visual Basic Express Edition

www.microsoft.com/express/vb

The SerialPort class provides two methods for reading bytes. The Read method can copy a specified number of received bytes from the receive buffer into a byte array beginning at a specified offset.

This example reads up to three received bytes, stores the bytes beginning at offset 0 in the byteBuffer array, and displays the result:

```

Dim byteBuffer() As Byte = {0, 0, 0}

myComPort.Read(byteBuffer, 0, 3)

```

The Read method doesn't wait for the specified number of bytes to arrive but returns when there is at least one received byte. If no bytes arrive, the method times out when the ReadTimeout time has elapsed.

Another option for reading bytes is the ReadByte method, which reads one byte at a time:

```

Dim receivedByte As Integer

receivedByte = myComPort.ReadByte

```

The ReadByte method reads a byte but returns an Integer with its high bytes set to zero. As with text data, Stream objects are another option for transferring binary data.

Moving On

Next time, we'll look at serial communications for microcontrollers. I'll show how to program a PIC microcontroller to detect and respond to commands received over a serial port. **NV**

Contact the Author

*Jan Axelson is the author of Serial Port Complete, now in its second edition. Jan's website is **www.Lvr.com**.*

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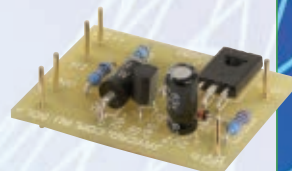


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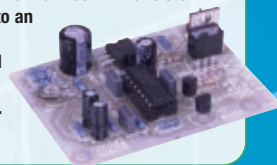
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Operating an Op-Amp on a Single Polarity Supply:

HOW TO TRICK AN OP-AMP

by Richard Schroeder

Many times during my illustrious career as an electronic hobbyist, I have designed devices that incorporated op-amps. As these projects usually operated from a transformer/rectifier type power supply, I would design the supply to produce both positive and negative voltages which would satisfy the op-amp. Nowadays, as it seems everything is battery operated, I find myself designing stuff around that very popular “nine volt battery” and more recently around five volt USB power.

Question: How does one connect a single polarity voltage source to an op-amp that wants to see both a positive and a negative voltage supply? While it is true that some op-amps such as the LM324 are designed to work with a single positive voltage source, they still won't handle ground referenced AC signals. (By the way, all the circuits shown assume the use of the LM324 op-amps or equivalent.) However, as noted, other types can be considered. Those “other types” will include the newer low power, low voltage, rail-to-rail jobs powered only by the five volt computer supply.

Here is a fact: Op-amps that are expected to handle ground referenced AC signals in a linear manner must see a negative supply voltage in respect to their input pins. This configuration sets both the input and the output points to average ground. Only in this way can the output swing an AC signal both positive and negative in respect to

the general circuit ground. Here is a problem: Connecting an op-amp to a single positive polarity supply does not allow the output to swing in a negative direction. In this case, a nice looking sine wave at the input will look like a half wave rectified signal at the output. Solution: Trick the op-amp into thinking it has a negative voltage supply. Here are some ways this can be done.

The “trick” is to elevate the input pins to half the supply voltage. This is accomplished by means of resistors R1 and R2 as shown in Figure 1. This, in effect, makes the normal ground pin look 4.5 volts negative in respect to its input circuitry. Our op-amp now has its negative supply and is happy. As shown, the circuit has an input impedance of 10K ohms and will produce a voltage gain of 10 (inverted).

Let us consider what might be called a downside to this configuration. Note that because both the input and output points have an average +4.5 volts stuck to them, coupling capacitors are needed to block this voltage from

FIGURE 1

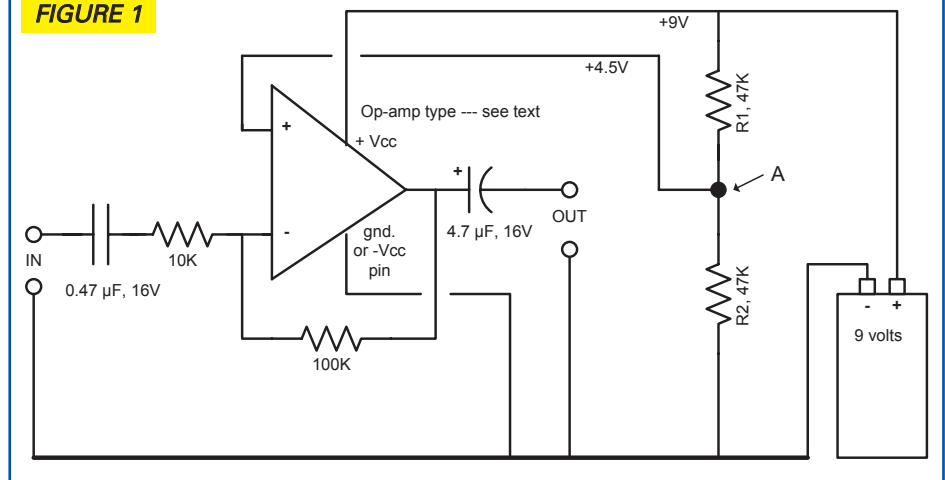
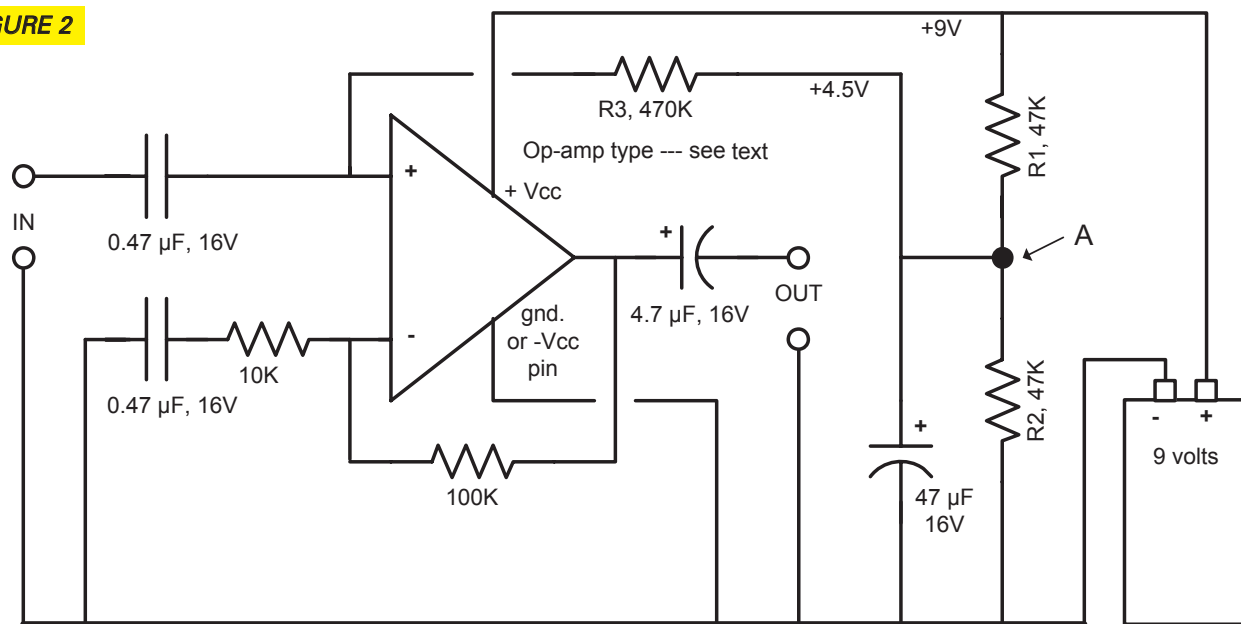


FIGURE 2



reaching associated circuitry. The value of these capacitors will have to be calculated so as to assure that the lowest frequency of interest will be passed on to the next device. Some typical values are shown. Now consider Figure 2. This is similar to Figure 1 except that this configuration does not invert the input signal polarity, which might suit your needs better. Note that an additional coupling capacitor at the “+” input, as well as a few other parts, are needed. As shown, the circuit has an input impedance of 470K ohms and a voltage gain of 11.

Figure 3 shows another way to make the op-amp see a dual polarity supply. This configuration has an advantage in that there is no 4.5 volt offset which eliminates the

need for input and output coupling capacitors. AC output signals can swing both positive and negative in respect to circuit ground, and input/output points are ground referenced which makes interfacing easier. Obvious, too, is that AC signals will respond all the way down to DC.

The trick here is similar to the circuits just described in that two equal value resistors are used to split both the battery voltage and polarity. To analyze this, consider that using their junction as a reference, the positive battery terminal will measure +4.5 volts and the negative terminal will measure -4.5 volts. As this junction becomes the common ground point, our op-amp sees a dual polarity supply. It's a sort-of pseudo center-tap for an otherwise

FIGURE 3

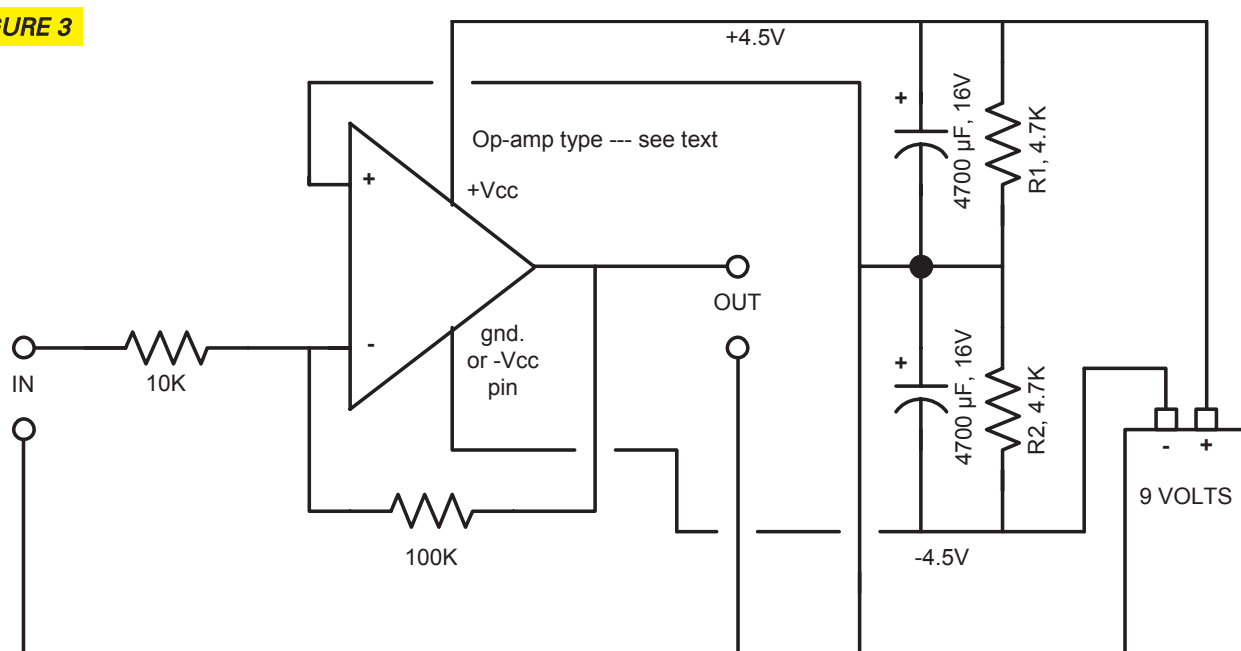
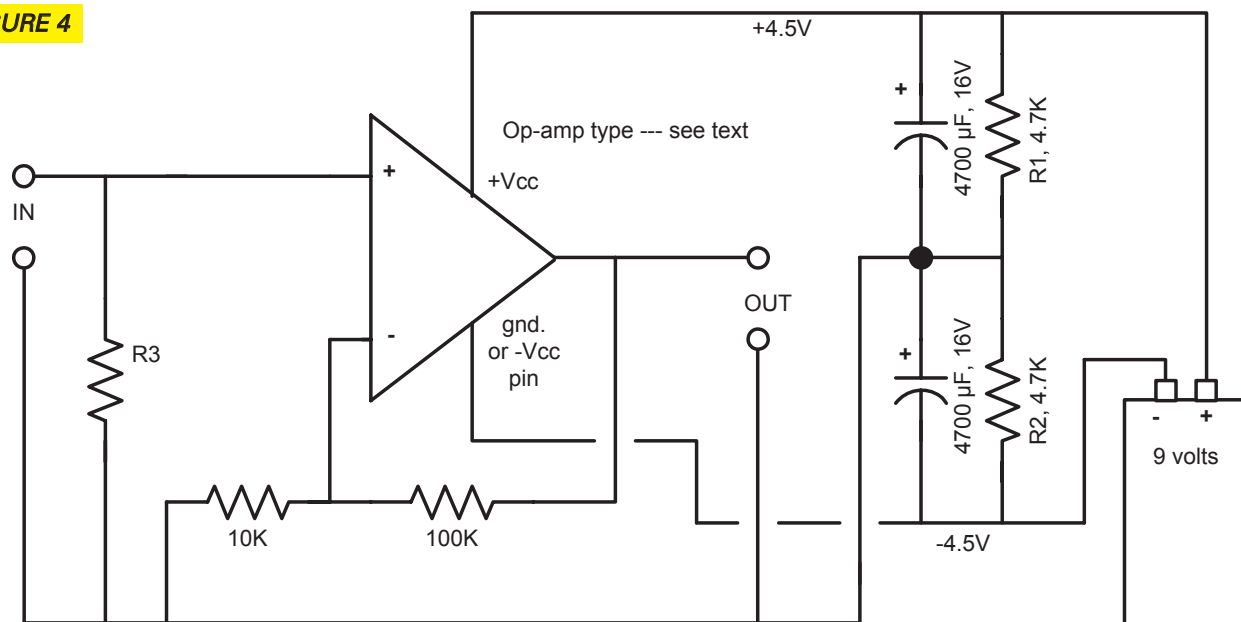


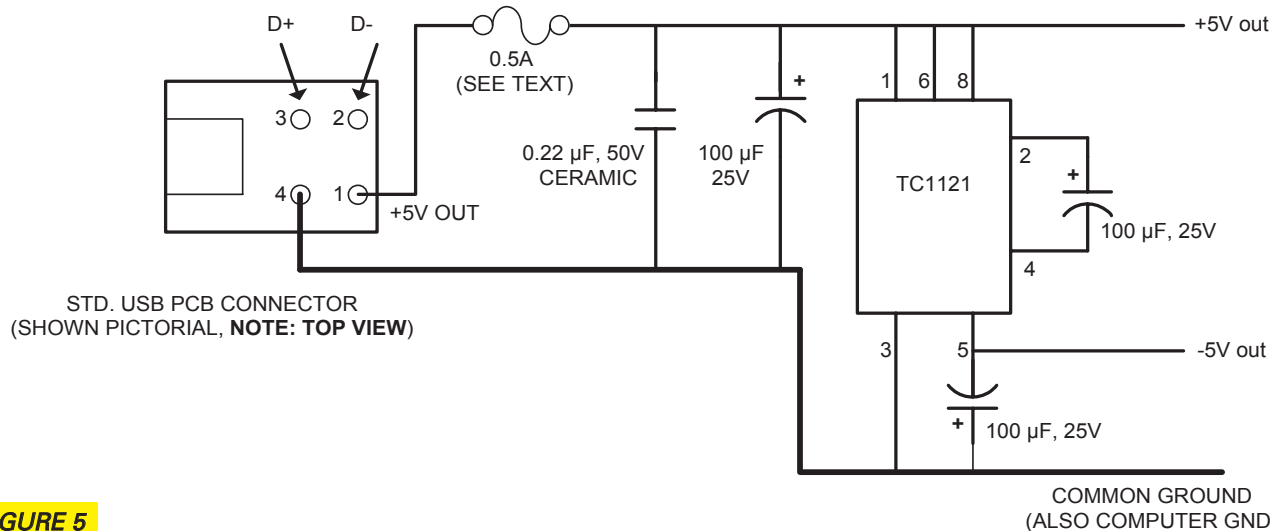
FIGURE 4

floating voltage source. The rather large capacitors across each resistor assure that the voltages will be stable when non-sinusoidal waveforms are present. As shown, this configuration has an input impedance of 10K and a voltage gain of 10 (inverted). Figure 4 shows virtually the same circuit but configured as a non-inverting amplifier. In this case, the input impedance is equal to whatever resistor you choose to use at the “+” input pin, and voltage gain is 11. Note: If you plan to use this configuration as a DC amplifier, output load currents must be kept to less than one milliamp. Currents greater than this will upset the DC polarity balance and produce gain errors.

A few words about maximum peak-to-peak output voltage: Theoretically, an op-amp powered with a nine volt battery should output 9V P-P. In actual practice, the figure will be somewhat less simply due to its internal design. Bi-FET type op-amps are the poorest performers in this respect,

however low power versions such as the TLO64 do somewhat better. The best performer is the already mentioned LM324. It works very well on nine volts, draws little current, and its output can swing just short of the total supply voltage. Even with these peak-to-peak voltage limitations, most designs can be made to work well with these levels. If your design requires the greatest P-P level possible from your existing supply – whether it be nine volts or five volts from a logic supply – you will want to use the newer low power rail-to-rail jobs. These are designed to work well on five volts – even less – and can swing the full power supply voltage, whatever it is.

CAUTION: If you plan to use these R-R devices on say nine volts or more, check the datasheets as some of these are only rated for a little over five volts. The configurations shown in Figures 1 and 2 would likely be the ones to use with a five volt supply and a R-R op-amp. Be sure to use all

**FIGURE 5**

of the components shown, minus the battery, of course.

For those of you that are marrying your analog circuits to a computer, you may want to consider the USB supply shown in Figure 5. This is a true dual polarity supply with enough muscle to handle large size analog/digital circuits. The positive part of the supply simply uses the existing five volts from the USB port, and the negative part uses "charge pump"

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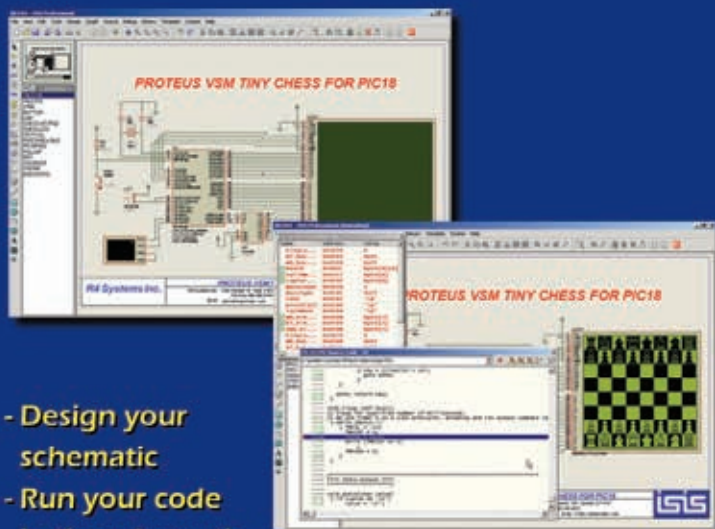
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TAMING WALL WARTS

by Kenton Chun

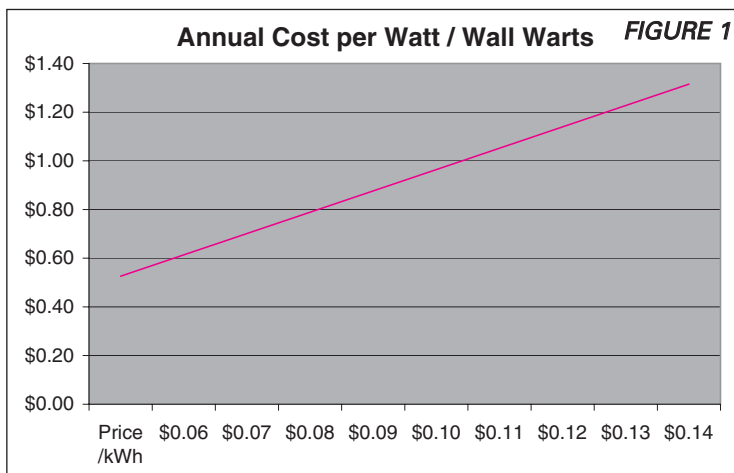
Here is an interesting experiment — try to turn off everything electrical in your home. Turn off the lights, heater, refrigerator, AC, TV, stereo, everything — then go out and look at your power meter.

Chances are good it is still moving. So what gives?

Probably lurking around your home are many small devices and appliances on standby, individually drawing nearly unmeasurable amounts of power; parasitic loads that collectively create a significant and constant power drain. According to a Lawrence Berkeley National

Laboratory study, the total annual power leakage in US homes is 45 terawatt-hours (45×10^{12} watt-hours). The annual cost to consumers for this is \$3.5 billion, and may even be closer to \$5 billion (based on a utility rate of seven cents to 12 cents/kWh). In a typical American home, the average parasitic power loss is estimated at approximately 50 watts/hr. In the face of rising energy costs, these energy losses are significant enough that in order to earn an Energy Star rating, TV and VCR OEMs must design their appliances to draw less than 4W in standby mode.

Now try another experiment and see if you can count all of the parasitic loads in your home. Ours is on the high side of the average. We have more than 50 wall warts from the attic to the basement and more than two dozen A/V (audio/visual) devices drawing standby power even when they are powered off. Our continuous “idle” power draw is almost 200 watts. This may not seem like much, but over an entire year, this adds up to almost a whopping two million watt-hours (1,753 kWh, or about \$210). At 12 cents per kWh, each parasitic watt burned will cost you about a dollar a year (Figure 1). Ironically, most often the devices that wall warts are connected to are not even on. The wall wart consumes power even if there is no load connected to it. If you were to break a few open, you would find that most of them are simply variations of



the old “brute force” power supply design — an AC step-down transformer connected to a bridge rectifier, filtered across a large electrolytic capacitor. Better versions will employ a linear voltage regulator IC, however, all but the very latest switching regulator designs will draw power continuously. Our small test bank of wall warts under no load drew 19 watts while powering nothing at all (Figure 2). How can you minimize the parasitic power loss in your own home? Following are some suggestions.

Classify Your Loads

Demand-Only:

This class of loads can save you energy and money very easily. Examples of these are boom boxes, radios, audio/visual equipment, anything that you only want drawing power if you are actually using them. These can simply be unplugged or switched off with a power strip to eliminate parasitic power loss.

Battery Chargers:

The majority of your wall wart loads will probably be in the class of battery chargers. Electric screwdrivers and power tools, razors, standby flashlights, portable laptop computers, cell phones, portable phones — all of these are examples of devices that are simply on charge whenever they are plugged in.

This type of parasitic load can be put on a timer to limit the time it spends drawing power from the utility. Group it together with others on a common power strip and put the strip on a timer so it is only on for a few hours a day. If the devices are located geographically far apart, use several timers, or an X-10 remote control system to power them up and down. An X-10 switch module will draw less than one watt in standby mode. This is a significant savings if you are controlling several wall warts.

Mission-Critical:

These are difficult to wean off power. They are devices like your answering machine, clocks, TIVO, fileserver, and things that may need power at any time of the day or night. The best way to deal with these is to simply limit the number of them.

Negotiable:

This class of load may save you money if you reconsider the operating environment, for example, your DSL/cable modem and router. You would normally consider these as mission-critical, but if you are not actually scheduling downloads overnight, they could actually be powered off for more than half a day. These devices usually reconnect automatically when powered up and shutting them down daily has the added benefit of increasing the security of your Internet connection by forcing the re-assignment of a new dynamic IP address on a daily basis.



FIGURE 2

Parasitic-Standby:

All of us have experienced the VCR that blinks 12:00 am whenever it is unplugged. This class of load must be tested. If your television forgets the channel list if it is unplugged, you are going to be forced to supply it power 24/7. If you can unplug it indefinitely without loss of data or settings, you can power it down without any problem and enjoy the energy savings.

Getting Creative

There are some interesting things you can do to minimize or eliminate the cost of powering some loads, especially in the battery charger class. One possibility is solar power. Take the dusty 50 watt solar panel in your garage out and set it up on a small inverter so it will charge your bank of battery charger devices whenever the sun is up. This will be completely automatic and “free” (less the cost of the solar panel), but it will at least be working to offset its initial purchase price. Remember not to overload the inverter or exceed the panel power capacity — your devices may draw full loads when initially powered up so calculate how many you can run with your

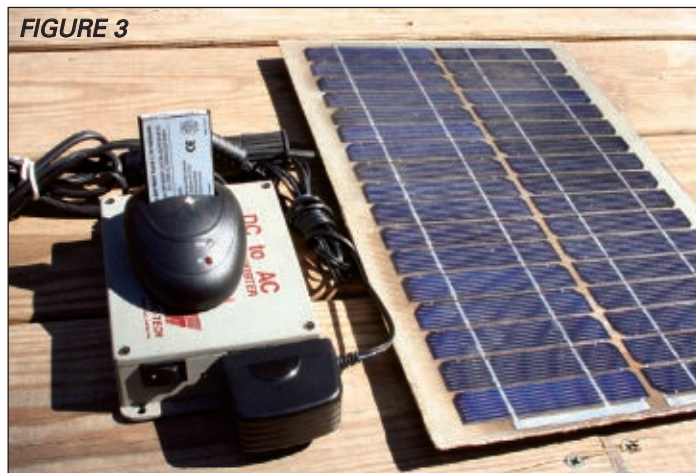


FIGURE 3



inverter. Several banks could also be split up on individual timers so they are powered on sequentially for a charge session. Even finicky lithium-ion (Li-Ion) batteries can be charged in this fashion (Figure 3).

Powering wall warts with solar panels will also help to recoup some of the inherent inefficiencies of less expensive power inverters. Cheaper inverter models will often have a significant idle power draw, consuming up to 10 watts even when no load is attached. Deploying these inverters on timers will cut their standby draw on the batteries to zero, but will still allow you to use them.

Even better is to take the DC output from the panel and charge batteries directly. By eliminating the inverter, you can gain some additional efficiency. You still will need to provide regulation to protect the batteries under charge. One cheap and dirty way to do this is to use a mobile multi-voltage power adapter — it is not the most

efficient converter, but it will hold the output voltages through swings caused by passing clouds and other weather changes (Figure 4). The balance you are working for is one between efficiency and convenience. An elegant setup will provide both convenient access to your appliances and be energy efficient.

Imagining this probably conjures images of a horrible DC power octopus in the center of your house — not a very convenient arrangement. One possible solution is to create a separate DC power distribution system within your home. This is actually easier than it sounds. Most homes have phone systems with at least four pairs of telco wires — a pair of these could be utilized to distribute low-current DC throughout your home to charge small devices.

In the old days, the telephone company actually used a pair of your internal phone wires to power the lights in your “princess” phones with — you guessed it — an 18 VAC wall wart. With local regulation, a solar panel or single DC power supply could be set up to provide trickle charging or efficient lighting power to all of the rooms in your home through existing telco jacks. Remember that if you use this approach, telco wire has a very small safe current carrying capacity of only a few watts.

Still another approach is to convert mission-critical or negotiable loads into battery charger loads. You can do this by using a deep-cycle battery to power an inverter which, in turn, runs these loads. This approach may seem complex, but it is fairly trivial to implement.

For example, we have a shallow water well and septic pump in a remote vacation home which we power in this fashion. When these loads cycle, they are drawing power from the battery directly, or through a load-sensing AC inverter. Otherwise, the battery is being charged by a solar panel. This method is especially effective for loads that cycle rarely or infrequently but require continuous availability.

Finally, another tactic is to automate power savings. For example, with a house full of kids you may find it is cost-effective to replace the light switch in the basement with an IR (infrared) sensing switch. This type of switch will turn the lights on when a warm body is in the room but after a set time interval without warm-body movement, it will turn the lights off.

This type of switch can also be set up to power appliances only when people are present. This is great for rec-room environments where devices like video games, TVs, and stereos should be off when nobody is using them. When the kids forget to turn the lights out manually, an IR switch can also save you energy and money in the long run.

Saving energy is a personal challenge that collectively can add up to a significant national effort toward energy independence. Start with taming the lowly wall wart and you can make a difference!

Remember to be safe, and have fun whatever you do! **NV**

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 A photograph of a Kill A Watt meter, a yellow device with a digital display showing '88.88' and several buttons. It is plugged into a wall outlet.



■ BY FRED EADY

WELCOME TO THE LAND OF CPLD

IF YOU'VE BEEN FOLLOWING DESIGN CYCLE, you know that we do lots of neat stuff with Microchip's family of PIC microcontrollers. When a new variant of the PIC goes public — such as the PIC32 — we most always need to ride the learning curve to figure out what we can do with the new part. That's what Design Cycle is all about. And, yep. I'm setting you up for something new. And, nope. This time it's not a PIC.

I was in the deep end of writing a *SERVO Magazine* article describing the ins and outs of the GeckoDrive stepper motor controller when the LED between my eyes started flashing. The GeckoDrive began life as a maze of individual CMOS logic ICs mixed together with through-hole and SMT support passives. Each CMOS logic IC in the early GeckoDrives contributed to the overall operation of the stepper motor drive by performing a particular and necessary logic function. For instance, one CMOS logic IC may have been full of AND gates while another was carrying a squad of inverters. Regardless of the logic IC payload, the final product depended on every gate to fulfill its logical obligation within the stepper motor drive system.

The newer GeckoDrive that I wrote about in the *SERVO* article had evolved from the earlier CMOS-logic-IC-laden variant. Instead of a brigade of individual CMOS logic parts, it contained a single Xilinx CPLD. Since it performed the same tasks as the original CMOS-IC-filled model, it was pretty obvious that the Xilinx CPLD contained all of the stepper motor logic that was embodied in the multitude of individual ICs formerly used.

In the past, I have used firmware

to package base logic functions such as AND, OR, NAND, and NOR in tiny six-pin PICs. As long as the PIC-based logic blocks didn't have to operate in the sub-millisecond range, the firmware-based PIC logic elements worked just fine. I was intrigued by the ability of that single Xilinx CPLD to stand in for the gaggle of CMOS logic ICs. Sure, a PIC could probably be coaxed into the Xilinx position, but the need for speed would force the use of faster logic to support the PIC microcontroller. That would mean more complexity and cost.

From my point of view (and obviously from the GeckoDrive designer's view), the Xilinx CPLD was fully capable of handling the CMOS logic and hardware replacement alone. Trust me. If we can come up with a way to use a Xilinx CPLD to enhance a PIC-based design, it will happen here. However, in this spin of Design Cycle we'll

concentrate of getting our arms around the CPLD.

With that last statement you've come to the conclusion that we are about to focus on putting CPLD devices into your Design Cycle. However, it may be wise to figure out what a CPLD is and where they came from before diving into how to program them. Once we can speak the CPLD language, then we will move into writing CPLD source code and putting the CPLD I/O pins to work for us in the real world. Our objective is to totally understand the device you see in Photo 1. Let's go to school.

■ **PHOTO 1.** The is a 144-pin XC2C256 Xilinx CoolRunner-II CPLD. It provides 118 pins of user I/O and contains 256 macrocells.



CPLD 101

I remember when a simple logic IC cost a dollar or more. Those same logic ICs today (if you can still find them) cost pennies per gate. I was cutting my teeth in the technocorporate world of the 1970s when I saw my first large-scale logic board, which was filled with 74-series logic ICs. That experience led to my acquisition of Don Lancaster's *TTL Cookbook*. I still have my well-worn copy of the *Cookbook*, which is sitting on the shelf beside his *CMOS Cookbook*. I was also discovering microcontrollers at the time, as well as dreaming of becoming a technical paperback writer.

As it turned out, I became proficient with melding 74-series TTL and 4000-series CMOS logic with the microcontrollers of the day and at times was given the opportunity to write about my exploits. I recall using 74LS138 three to eight line decoders with Z80, 8748, and 8751 microcontrollers. I was also heavy into designing with 74LS373 and later 74LS573 transparent latches, which tied the older

microcontrollers to external ROM and SRAM.

Over the years, I managed to accumulate thousands of various types of TTL and CMOS logic ICs. Today, we can replace most every one of those individual IC functions with a CPLD and do it one better. By using CPLD technology, we are no longer restricted to six inverters in a package or four AND gates per IC. I can synthesize as many inverters and multiple-input AND gates as the CPLD will allow. If the application is small, we can choose to deploy a small CPLD with a relatively lesser number of logic blocks. On the other side of that, we can lay down a very large CPLD footprint consisting of thousands of gates for those big NASA projects.

Ron Cline, who was then associated with Signetics, envisioned the CPLD (**Complex Programmable Logic Device**) concept. Ron's idea was based on a pair of programmable planes. The two planes could logically combine any AND and OR gate within the pair of planes. The AND output terms could also be shared with multiple OR

gates. This logic collection became known as a PLA (Programmable Logic Array). A simple PLA is shown graphically in Figure 1.

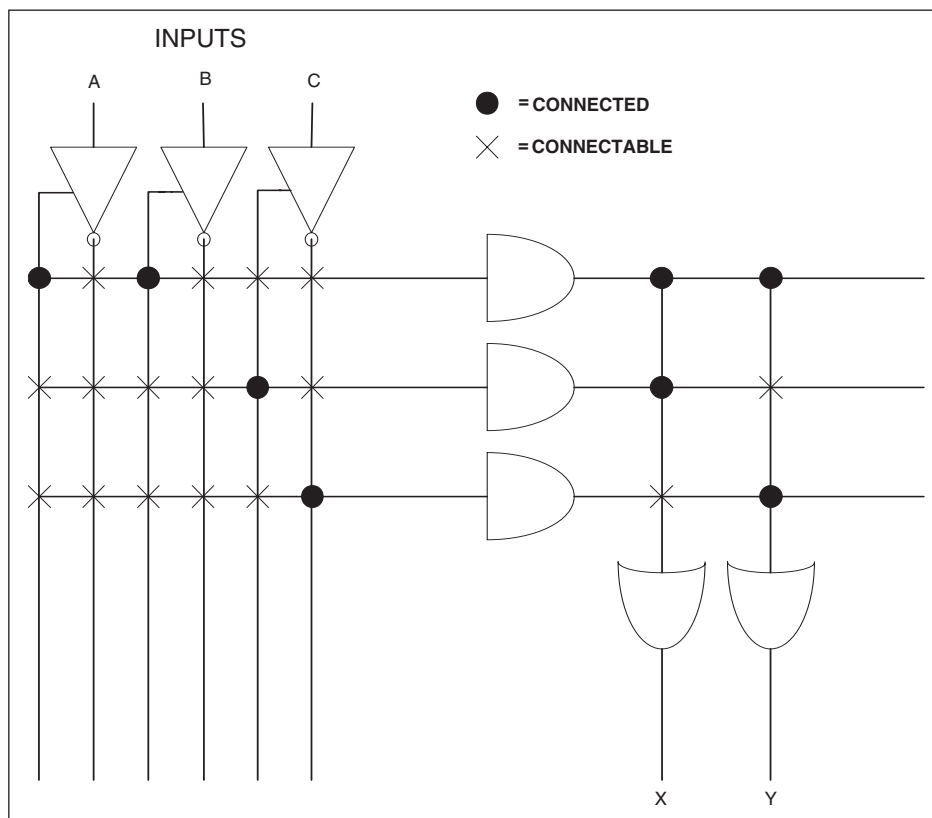
The complex matrix that really exists within the CPLD is replaced in Figure 1 by simple, single-line connections. The larger solid circles are connections, while the "X" markers are unused, open connection points that could be connected if the logic dictates. The buffered inputs A, B, and C are complemented with inverters. Each input buffer output and each inverter output is fed into the AND gate input matrix. The outputs of the AND gates feed the inputs of the OR gates, which are also available via a matrix.

Now that you understand the graphical logic layout, let's solve for output X, according to what we see logically connected in Figure 1.

Using Figure 1 as a guide, we'll resolve output X from left to right, top to bottom. The first logical connection is input A, which is followed by an identical logical connection at input B. Since both A and B inputs are feeding an AND gate, we can write this in sum of products form as $A \& B$ ($A \text{ AND } B$). The connection at the A & B AND gate output is connected to the input of the X OR gate, which ultimately provides the X output value.

If we were to stop here and evaluate nothing else, $X = A \& B$ is our answer. However, the X OR gate has yet another input for us to consider. Moving down to the next AND gate, input C is being routed via the AND gate to the X OR gate input. Our logical conclusion is now $X = A \& B \# C$ ($X = A \text{ AND } B \text{ OR } C$).

One of the advantages to using a PLA is that logic can be shared. We can clearly see this in our first pass solving for output Y. At this



■ **FIGURE 1.** Nope. No matter how magical a CPLD may seem to be, there are no single input AND or OR gates contained within the CPLD. The single connections to the AND and OR gates are symbolic of the matrix connections. Having a single line instead of hundreds of lines going into a gate makes it easier to grasp the logic of the situation.

point, $Y = A \& B$. When we passed this way before, $X = A \& B$. The A & B logic is shared by the X and Y outputs. The C input does not play into the Y output as the C product term (another name for the AND gate accepting the C input) does not matrix into the Y output OR gate.

The next input that affects output Y is a !C (NOT C). The !C input ultimately ties into the Y output OR gate just as the C input tied into the X output OR gate. So, our equation for the Y output is $Y = A \& B \# !C$ (A AND B OR NOT C).

As good as the logic of the PLA was in the 1970s, it was difficult to fabricate with the technology of the time. The PLAs of the day were also operationally slow. Around the middle of 1978, Monolithic Memories, Inc. (MMI), got into the PLA mix and “fixed” the OR array of the PLA. In this case, fixed means not programmable. The fixed OR plane device became the PAL (Programmable Array Logic). PALs at the time were faster and easier to program than the Signetics FPLA (Field Programmable Logic Array), which had been on the market for three years at this point. A graphical view of PAL logic is depicted in Figure 2. The immediate differences you should see in Figure 2 are the extra product term (AND gate) and the dedicated output OR gates. In the PAL or SPLD (Simple Programmable Logic Device) architecture, each product term (AND gate) has a dedicated output OR gate. That means no logic sharing is possible at the product term levels.

Solving for X in Figure 2 yields $X = A \& B \# C$. Note that we have no shared A & B logic in Figure 2 and solving for Y is done on the lower pair of product terms, which comes to $Y = A \& B \# !C$. The logical output for both the PLA and PAL devices is the same in the end. However, as you can clearly see in Figures 1 and 2, the internal structure of the hardware between the PLA and PAL

architectures is very different.

Early PALs were programmed by blowing the unwanted fuses at selected junctions. We won't be blowing any fuses as the CPLDs we will be discussing are programmed and erased electrically. So, put that UV eraser back into the closet and study Figure 3, which just happens to be a high-level model of the CPLD we will be logically manipulating.

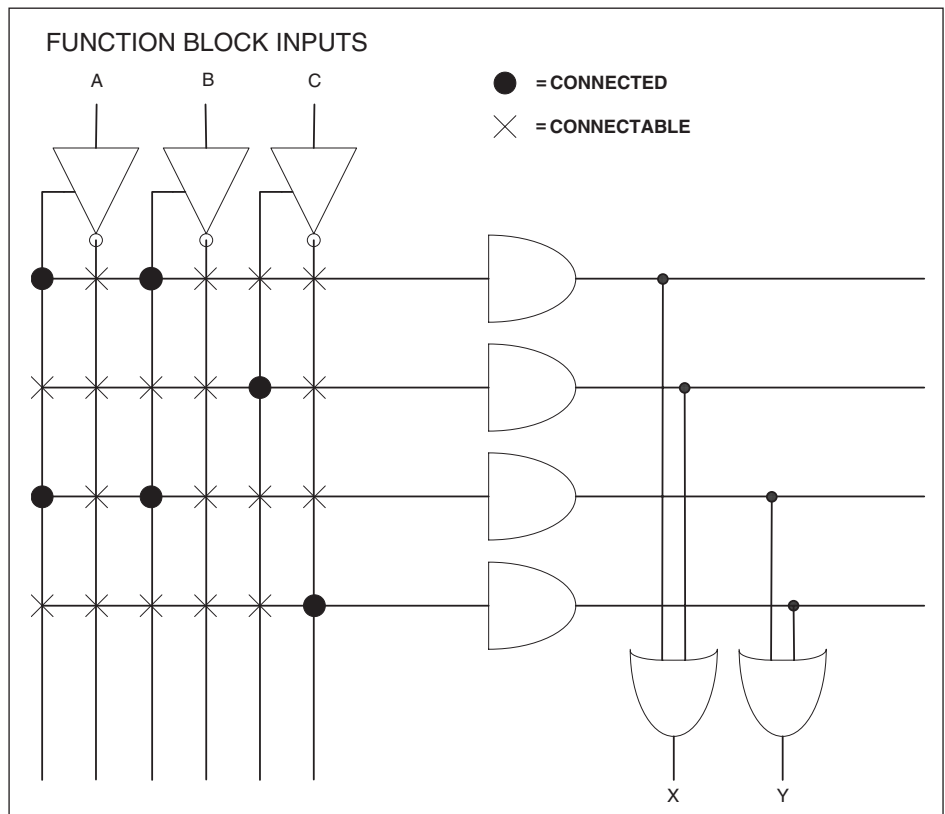
THE XILINX COOLRUNNER-II

I've taken the liberty to Xilinx-ize the functional block names of the high-level CPLD model you see in Figure 3. A generic CPLD may contain PAL or PLA architecture in its SPLD blocks. AIM (Advanced Interconnect Matrix) is a Xilinx CoolRunner-II term for interconnect array. The idea behind the CoolRunner-II is to allow connections and interconnections to all of the CPLD resources via the AIM. The Xilinx technical documentation states that its CPLD design software is so

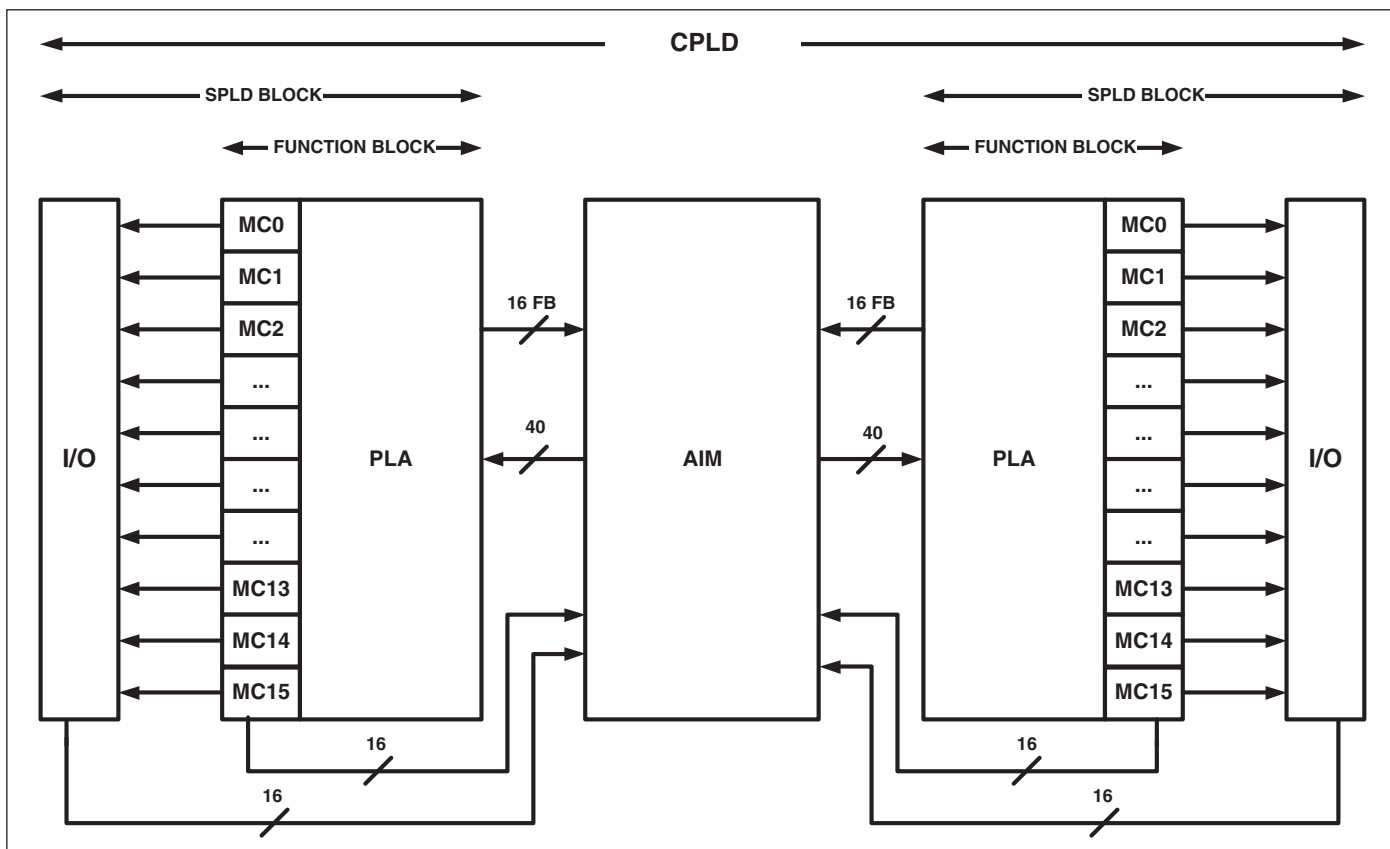
good that one doesn't need to understand how the CoolRunner-II works to use it in a complex design. I don't quite agree with that as I couldn't imagine trying to use a PIC I/O port without knowing what is behind a PIC's I/O port hardware architecture. So, before we start generating logic with the Xilinx CPLD design tools, let's take a closer look at what's inside of a CoolRunner-II CPLD.

We already know some things about the CoolRunner-II. For instance, we know that its PLA logic arrangement will allow the CoolRunner-II to share logic terms. The PLA architecture will also play into the hands of the Xilinx CPLD design tool software as many more routable logic paths are available.

As you can see in Figure 3, the PLA and 16 macrocells (MC0-MC15) make up a CoolRunner-II FB (Function Block). Forty signal entry points are provided for each CoolRunner-II FB. The FB is a place where logic and connections necessary to complete a logical function are created. You have already been introduced to the



■ **FIGURE 2.** There is an extra product term (AND gate) here. It's needed because we can't share the A & B logic with the X and Y outputs.



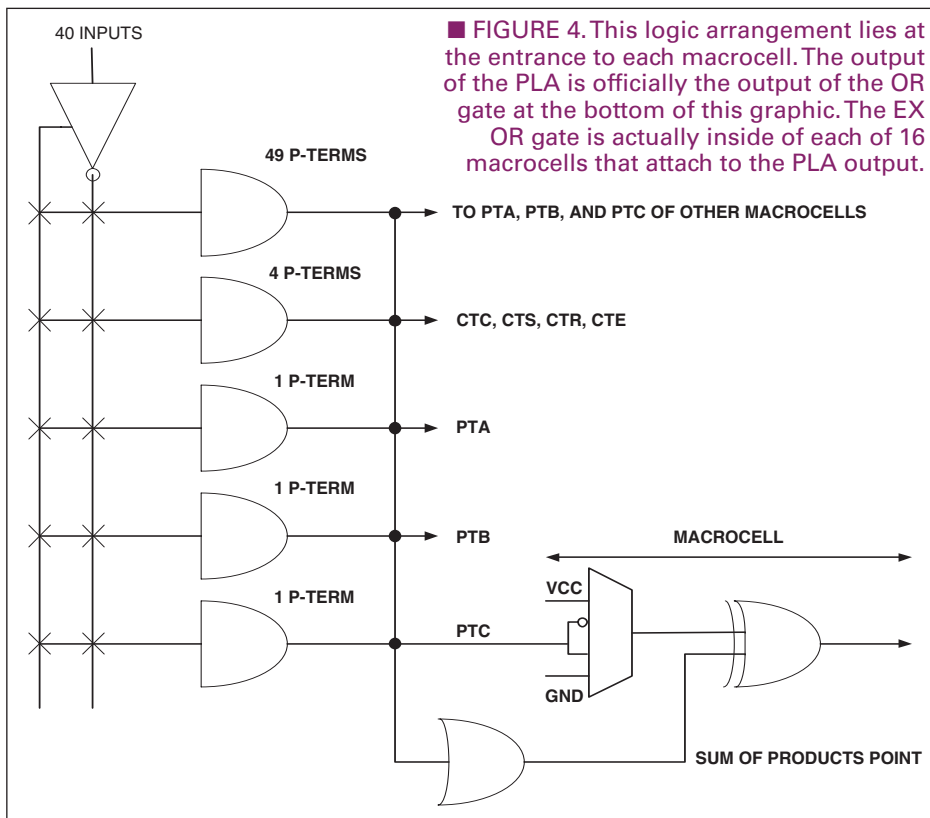
■ **FIGURE 3.** With arrows pointing to everything everywhere, it's easy to see that the internals of this particular CPLD are fully interconnectable.

CPLD nomenclature "product term," of which the CoolRunner-II has 56 of within each of its identical PLA

structures. Product term is the mathematical name for an AND gate. Within the CoolRunner-II, any product term can be attached to any OR gate inside of the FB macrocells. When you study the Xilinx CoolRunner-II documentation, you'll often see product term abbreviated as "p-term."

Recall the advantageous PLA characteristic of logic sharing. Any logic function residing in an FB can have as many p-terms as it needs, up to a maximum of 56. Remember our logical product of $X = A \& B$ and how it was used by both the X and Y outputs in a PLA? We need only create a logical product like $A \& B$ once. We can reuse that product up to 16 times within the FB.

In other words, each macrocell can share the same logical product. The Xilinx CPLD design software automatically checks for product terms that can be shared and performs the necessary sharing assignments without human programmer intervention. Thus far, we've been talking about AND and OR gates, which can be connected



in fancy manners to create some really complex logic solutions. We now know that we can have as many as 40 inputs and up to 56 p-terms in an SOP (Sum Of Products) logic expression that resides within a single CoolRunner-II FB.

The 40 inputs are routed to the PLA by way of the AIM. Logic combinations produced within the PLA are routed to the FB's 16 macrocells. The CoolRunner-II macrocells do their logic thing with the incoming signals using OR gate sum terms (X and Y outputs in Figures 1 and 2) and then route signals back to the AIM or out of the CoolRunner-II's I/O subsystem.

We now have a handle on the basic operation and logic behind the CoolRunner-II PLA. Let's dig a bit deeper.

Take a look at Figure 4. Taking inventory, we see 40 inputs feeding a total of 56 p-terms. All of the PLA p-terms spill into an array of OR sum term logic. The PLA OR array is attached to the OR gate at the bottom of Figure 4. The PLA OR gate output that is feeding the EX OR (Exclusive OR) gate input represents the SOP output of the PLA. The EX OR gate is actually part of the macrocell. Thus, there are 16 EX OR gates leading to 16 macro-cells, which are all attached to the PLA output.

The EX OR gate is situated here for flexibility and works hand in hand with the mux attached to its other input. The mux is also a component of each macro-cell. The mux inputs include a logical high (VCC), a logical low (GND), a p-term, and a complemented p-term. Muxing in the VCC line to the EX OR input complements the PLA output signal (OR gate output in Figure 4) entering the macrocell. Muxing in GND (Ground) passes the PLA output signal as-is. Choosing to mux VCC forces the EX OR gate to become an inverter, while muxing in GND uses the EX

OR gate as a noninverting buffer input to the macrocell.

The p-term feeding the mux is used to bypass the PLA output OR gate. This connection provides a very fast path to an I/O pin or the flip flop inside of the macrocell. This logic is commonly used to support fast switching for microcontroller address decoding. Can you say 74LS138?

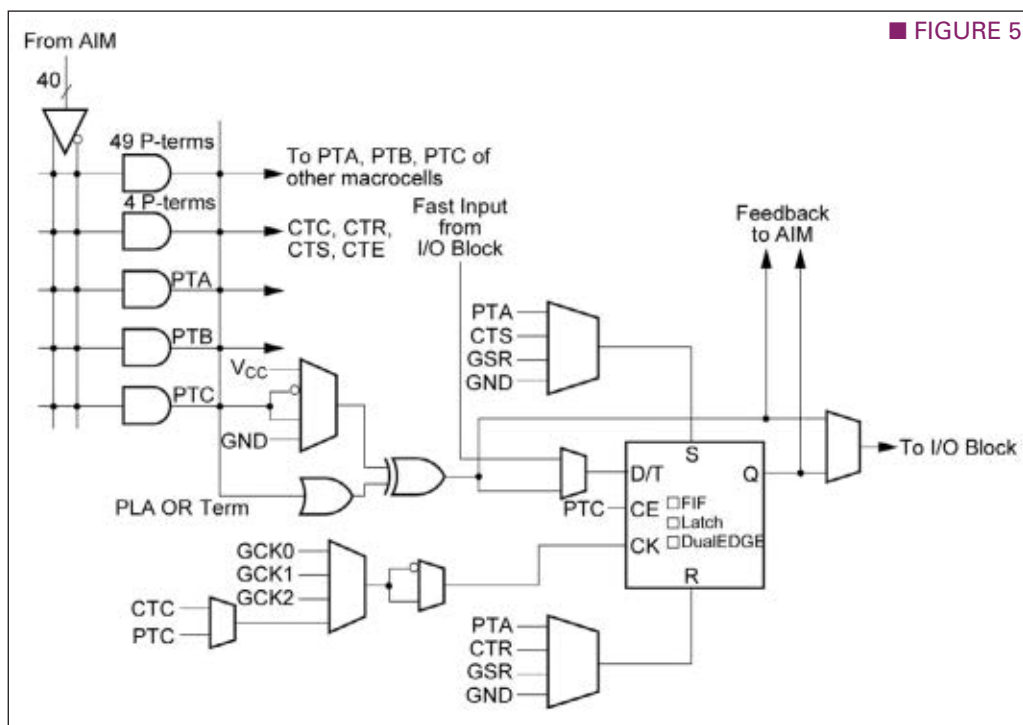
The rest of the macrocell structure is fleshed out in Figure 5. If you simply match up PLA p-term outputs with macrocell mux and flip flop inputs, you can instantly see how macrocells are affected by the PLA. The macrocell flip flop can be controlled as an SR (Set Reset) flip flop by using the CTS and CTR p-terms. Depending on the logic requirements, the PTA p-term can also be used to either set or reset the flip flop. Everything beginning with “G” in the macrocell – with the exception of GND – is a Global signal. Global means just that. The global signals are common to all of the CPLD resources. The CTS and CTR terms I mentioned are available only within their associated FB.

To help you keep up with how the CoolRunner-II resources are distributed, let's look at what is actually owned by a macrocell and

what is shared by a macrocell.
Product term resources (signals) are only available to the local macrocell.
For instance, macrocell 1's PTA p-term signal is not the same as macrocell 2's PTA p-term signal.
That means that we can't directly drive macrocell 1's filp flop R input with macrocell 2's PTA p-term signal.

What if we needed to drive macrocell 1 and macrocell 2's R input with the same signal? That's where control terms come in. As you can see in Figures 4 and 5, four control terms (CTS-FB SET, CTR-FB CLR, CTC-FB CLK, CTE-FB Output Enable) are provided that connect to the same mux points within every macrocell in the FB. The control terms eliminate the need to dedicate a noncontrol p-term in each macrocell to perform an identical function across macrocells such as resetting or setting the flip flops of multiple macrocells. Thus, as I alluded to earlier, control terms are p-terms that are available only to the macrocells within the FB that owns them.

To take the control term concept one step further, suppose we wanted a common clock but wanted each macrocell to perform a set or reset on its own flip flop as required? No problem! The CTC p-term would be



■ FIGURE 5

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SOURCES

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CoolRunner-II CPLD

used in each macrocell to provide a clock signal for the flip flops. We could then use the PTA p-term to set the flip flop in macrocell 1 and macrocell 2's PTA p-term to reset its flip flop asynchronously with respect to the common clock signal.

FINAL THOUGHTS

Take some time to study Figure 5 and roll in the things we've discussed. You'll find that the idea behind Figure 5 becomes less complicated as you work through its basic logic. For instance, it's easy to see how registered signals (Q output of the flip flop in Figure 5) and combinatorial signals (output of the EX OR gate) get routed to either the AIM or the CoolRunner-II's output subsystem. Remember that you really don't have to know how to manually connect the p-terms and control terms within the FB. That's all done by the Xilinx CPLD development tools. Our goal here is to gain an understanding of what is happening behind the scenes, which will help us when it comes time to lay down our logic patterns in the CPLD source editor window.

NEXT TIME

When we meet again, we'll flow through CPLD 201 and put together some CPLD hardware. We will also do some CPLD Coding 101 and see if we can't do with a CoolRunner-II what we always do with new PIC microcontrollers ... Flash some LEDs. Once we are able to feed the CoolRunner-II inputs and get some light from the CoolRunner-II outputs, we'll be ready to put a CoolRunner-II CPLD into our Design Cycle. See you next time! **NV**

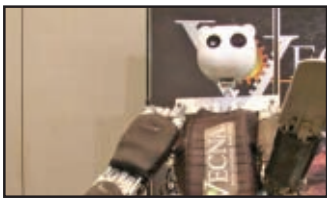
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■ **Fred Eady** can be contacted via email at fred@edtp.com.

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■ BY LOUIS E. FRENZEL W5LEF

WI-FI MAKES INTERNET RADIO WIRELESS

One more option for the radio enthusiast

You just don't know how lucky you are. Just think of all the options you have in listening to radio. There are the old standbys like AM and FM stations that most of us still listen to mainly in the car. There are thousands of stations nationwide and dozens in your local area. Then there is the newer HD radio that puts digital broadcasts into the AM and FM bands for higher fidelity, better noise, and fading immunity, and more station choices. With well over one thousand stations nationwide, you probably have several HD stations locally.

Satellite radio is another form of digital radio. With either Sirius or XM satellite radio, you have almost 200 stations each to choose from. And don't forget shortwave radio. Most of you don't listen to this but there are hundreds of English language stations worldwide. Then, of course, you have Internet radio.

WELCOME TO INTERNET RADIO

Internet radio is really a misnomer. It isn't really radio as such meaning receiving signals wirelessly as in all the other forms of radio. Instead, Internet "radio" is getting audio broadcasts via the Internet. You listen to talk, news, and music on your PC or laptop via the browser and sound capabilities. If you have never tried it, you need to experiment. It opens up a whole new world of listening possibilities. There is something for everyone, even wild stuff the FCC doesn't allow over the air waves.

The audio to be broadcast is digitized in an analog-to-digital

converter (ADC) then put through an audio compression process. The resulting compressed digital data is then serialized and sent out over the Internet via TCP and UDP packets. We call this streaming audio. These audio packets pass through one or more servers or routers before hitting your PC. There is a lag or delay as this happens but you don't really notice it unless a particular server or router gets overly busy; you will hear jerky spaced out chunks of audio.

The audio is compressed to reduce the number of bits to be transmitted. If you want to transmit hi-fi audio with CD quality, that means you need to cover up to 20 kHz signals. This requires sampling the audio in the ADC at least twice that (or 40 kHz). The digitizing rate in a CD is 44.1 kHz. Let's say we have a 16-bit ADC that samples at this rate. That means we are transmitting 16 serial bits for each sample. That translates into $16 \times 44.1 \text{ kHz} = 705.6 \text{ kHz}$ or 705.6 kilo bits per second (kbps). If you are transmitting two channels for stereo, the data rate goes up by a factor of two or 1.4112 Mbps. You need a high speed

Internet connection like cable or DSL to hear this. The answer to this problem is to compress the audio.

You digitize the audio as just described and store it in a memory. Then you subject that audio data to a compression algorithm that effectively reduces the number of bits and words that need to be transmitted. The data rate can be much lower.

Examples of digital audio compression algorithms are the familiar MP3 and Apple's iPod AAC standard. There are many others like Windows media files or RealAudio. And keep in mind when you are storing digital audio on a disk or in a Flash memory inside an MP3 player or iPod, the compression technique greatly reduces the number of bits and words you need to store, and therefore the size and cost of the memory. To listen to Internet radio, all you do is go to your PC and open the browser and search for Internet radio stations. Many of the available stations are just your local stations streamed to the Internet. You can listen to them on the PC — no radio needed — and you can do that from any place in the world that has an

Internet connection.

There are thousands of Internet radio sources worldwide. Most sources say that there are over 10,000 stations in the world. There are a few databases that identify these but they are only accessible if you want to pay a fee. Otherwise, you can access any of the stations but you do have to search for them one at a time. With over 10,000 choices, you can listen to any kind of music by category, or news, or just talk and opinion. If you start searching, you will see just how overwhelming this is.

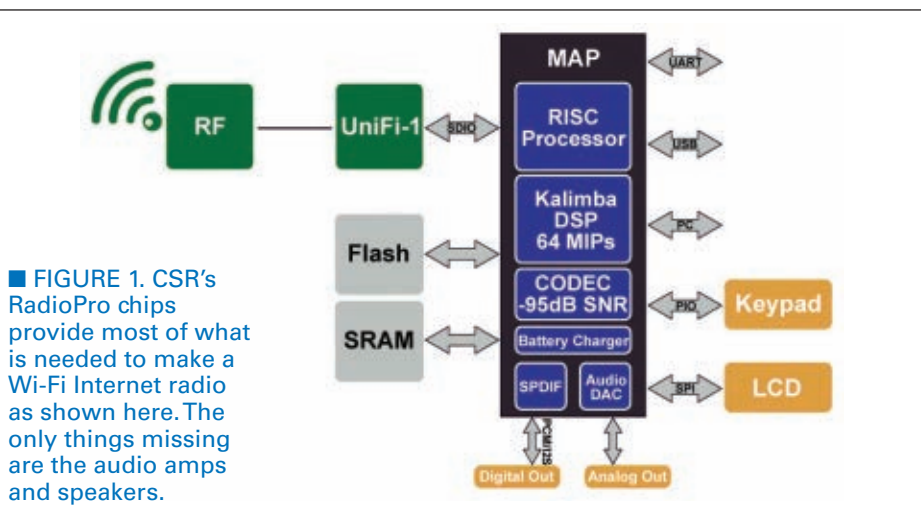
My biggest complaint about Internet radio is not so much with the sources, but with the hardware. My PC or laptop does not have good audio, especially the laptop with its tiny speakers. The desktop PC with its larger speakers is better. And the volume is never enough for me. But when I listen, I usually use earphones which helps. At least you can connect your PC to an external audio system with bigger power amps and speakers. And like I said, the fidelity is almost CD quality.

WI-FI BRINGS WIRELESS TO INTERNET RADIO

As I said earlier, Internet radio is not wireless. But the latest development makes it so. It uses the popular Wi-Fi wireless local area network (WLAN) technology. The term Wi-Fi means “wireless fidelity” and that is the trademark of the Wi-Fi Alliance — an organization of companies that make and support Wi-Fi equipment. The Alliance also certifies the equipment to ensure interoperability and compatibility between different vendors.

Also known by its IEEE standard designation 802.11, Wi-Fi wireless technology is widely used in business and industry to extend Ethernet LANs. With wireless access points connected to the company LAN, an employee can get on-line for email or whatever with a laptop from any physical location.

Wi-Fi service is also available through access points called “hot spots” in airports, hotels, and other



public places so you can connect to the Internet and check email. There are tens of thousands of these hot spots around the world. Today, virtually all laptops come with a Wi-Fi transceiver built in. Wi-Fi is also widely used in homes for networking two or more PCs to the Internet via a DSL or cable modem.

Here's how Wi-Fi Internet radio works. When the Wi-Fi Internet radio gets close to a Wi-Fi access point at a hot spot or in your home, it automatically establishes a connection. You do not have to do anything. The radio then connects to a portal on the Internet where a database of Internet stations is cataloged. The radio gives you lists by category and all you do is select what you want. The desired station is automatically accessed.

The audio is then streamed to the radio that converts the compressed audio back to regular digital format. The digital data is then sent to a digital-to-analog converter (DAC) to recover the analog audio which is then amplified and played through a speaker or headphones.

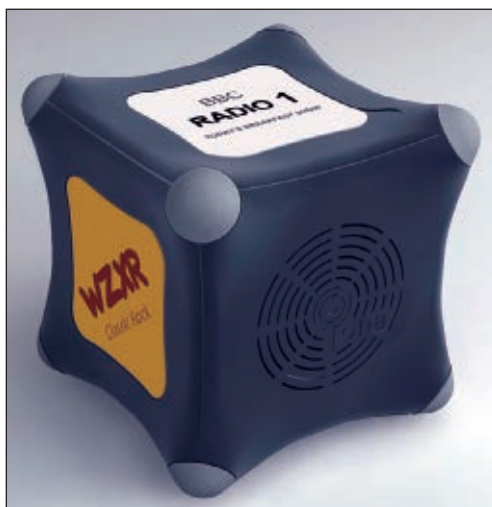
Several companies have recently announced chipsets that are set up to connect to any access point or hot spot via Wi-Fi and to access Internet radio without a PC. This means that you can make

an ordinary radio connect wirelessly through your home or office access point. It then lets you select one of the 10,000 or so Internet radio stations. Finally, Internet radio is wireless.

Figure 1 shows a block diagram of an Internet radio implemented with the RadioPro chips from CSR (Cambridge Silicon Radio). CSR is a British firm who dominates the Bluetooth wireless chip market but also makes 802.11 chips and GPS receiver chips.

In the figure, the UniFi-1 block is the CSR 802.11b/g transceiver. The RF box contains the antenna transmit/receiver switch, low noise amplifier (LNA) for the receiver, and a power amplifier (PA) for the transmitter. The MAP (multimedia applications processor) is CSR's baseband processor chip. It contains a RISC processor that controls all the basic operations (channel selection,

■ **FIGURE 2.** The Cambridge Consultants Iona Cube radio. Just rotate the cube to select one of four favorite stations.



A DSP core processor and the 16-bit CODEC handle the decompression and related tasks. It accommodates MP3, WMA, RealAudio, and other formats. The DACs for conversion to analog output is also on this chip. Note the connections to both 4 Mb of SRAM for temporary buffer storage of the audio data as it streams in and a 32 MB Flash memory for program storage.

Interfaces for the external keyboard and LCD displays are provided. The audio amps are not shown here as they are on a separate chip. All the regular security features (encryption, etc.) of the 802.11 standard like WEP, WPA, and WPA2 are supported.

A key feature of the RadioPro chips is its very low power consumption that really makes it possible to put Internet radio into portable battery-operated devices and still

have a long play time. Another feature is the vTuner portal connection that lets you browse and search for over 10,000 radio stations. The chip set supports the Wi-Fi Alliance's Wi-Fi Protected Set Up feature that lets you set up the radio with two button clicks: one click on the radio and another on the access point or router. The two devices exchange security keys and the link is established.

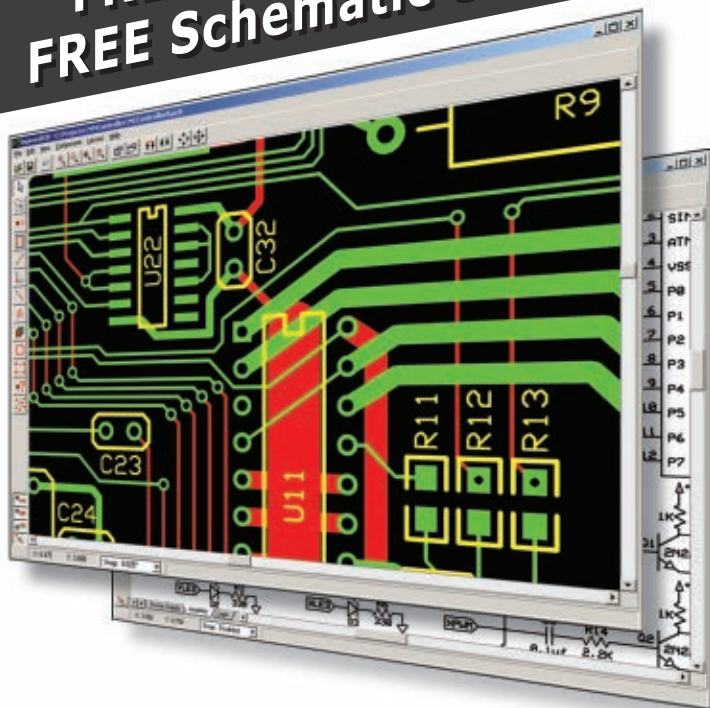
CSR also has an association with NTEEP – a Hong Kong module maker who builds a complete radio module with all components, including the RadioPro chips. A manufacturer can buy the module and drop it right into any other product with no further design.

A unique Wi-Fi Internet radio design from Cambridge Consultants (www.cambridgeconsultants.com) is based on the CSR RadioPro chips. It is called the Iona Cube radio (see Figure 2). It allows you to select one of four of your favorite Internet stations by just rotating the cube to one of its four sides. The other two sides are for the speaker and the controls.

WHERE IS ALL THIS HEADED?

You can buy a Wi-Fi Internet radio today. For example, Best Buy has one called the Grace Digital Wireless Radio. Other dealers may have some as well, and you can certainly find a source on the web if you search. Mail order radio company C. Crane has a Wi-Fi Internet radio called the Quattro. (www.ccrane.com) The popular shortwave radio maker Sangean has a Wi-Fi radio called the WFR-20. It is still early in the product marketing game, so expect more models to come. And that's not all. CSR predicts that by 2009 about 40% of MP3 and other music players — maybe even iPods — will have a built-in Internet Wi-Fi radio. It is also expected that as many as 50% of satellite radios will have a Wi-Fi Internet radio and as many as 30% of home hi-fi stereo systems could have an internal Wi-Fi Internet radio. **NV**

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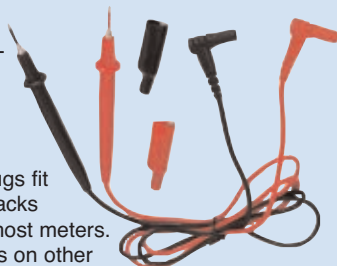
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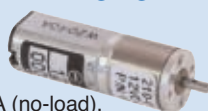
Red and black multi-meter test leads. Shrouded right-angle banana plugs fit recessed jacks found on most meters. Test probes on other end are threaded to accommodate alligator clips. 33" long leads.
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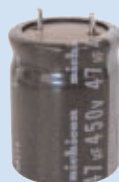
Sayama #12SM-AT3. Compact, good-quality 12Vdc gearhead motor. 58RPM, @ 12Vdc, 20mA (no-load). 12mm diameter x 35mm long. Solder-lug terminals. 2mm diameter x 6mm long flattened shaft.
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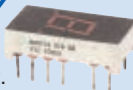
12 Volt halogen lamp and ceramic socket with mounting frame. Lamp is standard 71W, MR-16, bi-pin lamp. Socket and frame can be used with any MR-16 reflector lamp. Solid metal frame has spring clip to hold lamp securely in place. Mounting holes on front side of frame. 6" heat-resistant leads, prepped with Molex-type connector.
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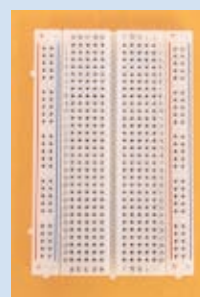
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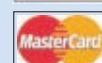
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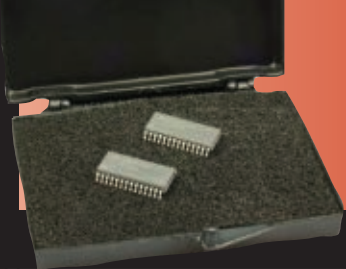
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■ BY RON HACKETT

GETTING STARTED WITH STRIPBOARD CIRCUIT CONSTRUCTION

IF YOU HAVE BEEN READING THE PICAXE Primer or any of my articles in *Nuts & Volts* and *SERVO Magazine*, you know by now that I am very partial to working with breadboard circuits. I think they are by far the fastest and most flexible approach to building and debugging a PICAXE-based circuit, or any small circuit for that matter. However, sooner or later you may want to construct a circuit that is more reliable and “permanent” than a breadboard circuit

One approach, of course, is to design and fabricate a printed circuit board (PCB) using a laser printer, some type of transfer paper, and an ordinary household iron to transfer the pattern to a copper-clad board for etching. With practice, this method can produce a very professional looking PCB.

However, there are drawbacks: it is complicated and time-consuming; mistakes can be very difficult to correct; and it requires messy (and possibly toxic) chemicals.

STRIPBOARD CIRCUITS

There is another approach to constructing a hard-wired version of a

breadboard circuit that is very popular in Europe, but not yet widely used here in the United States. It is usually known as “stripboard” circuit construction, but stripboards are also frequently referred to as “Verobboards” (the most popular brand of stripboards) and even sometimes as “protoboards” (although stripboards are actually a sub-category within the larger category of protoboards).

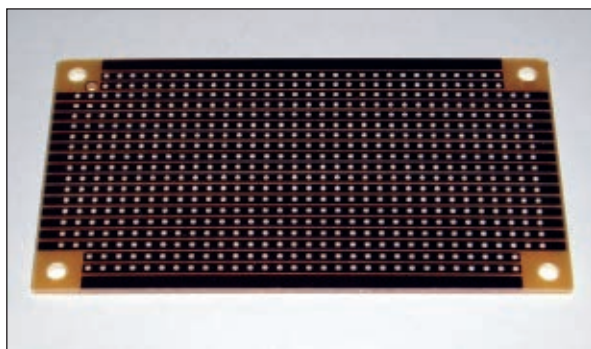
Figure 1 is a photo of the bottom side of a typical stripboard, which essentially consists of a matrix of holes evenly spaced on a 0.1-inch grid and connected by rows (or columns) of copper traces. If you have difficulty locating stripboards on your own, the one shown is available on my website (see the Sources sidebar).

The most difficult aspect of constructing a stripboard circuit (at least for me) is figuring out how to lay out the circuit in the simplest way that conforms to the limitations of the

stripboard matrix. This can be very challenging at first, so it’s best to start with very simple circuits. With practice, however, it does get easier. If you like spatial puzzles, you will love working with stripboards.

Simple stripboard circuits can be designed by hand, using nothing more than a pencil (with a large eraser!) and a piece of graph paper — the trick is to remember whether the copper traces are running horizontally or vertically. To make this easier, you can use one of the online graph paper programs (listed under Sources), and print out your graph paper with darker lines in one dimension and lighter ones in the other. However, there is a problem with this approach, in that it is necessary to be able to view the stripboard layout from the bottom of the board as well as from the top, because the copper traces on the bottom must be cut at specific points to correctly implement any circuit. (We’ll get into that in more detail shortly.)

When I first started working with stripboards, I dealt with this problem by holding the graph paper in front of a bright light and viewing it from



■ FIGURE 1. Bottom view of a typical stripboard.

the back of the paper to view the bottom layout. That worked, but it certainly was a nuisance. If you have access to a scanner, you could scan your layout and use a graphics program to flip the image. That way, you can print out a top view and a bottom view, which makes the process much easier.

Before long, you will probably want to use a PC-based CAD program to do your stripboard layouts. If so, you have two basic choices. The first option is to use a program designed for regular PCB layouts, but to use it within the constraints of the stripboard. The advantage of this approach is that very functional software is available for free. For example, ExpressPCB (see Sources) provides free downloadable software that can be used to design PCBs that they will manufacture. Their file formats are proprietary, so they can't be used anywhere else. However, you can easily use the ExpressPCB software to design a stripboard layout and print it out for your own use.

All you need to do is to design a two-layer board with the stripboard traces running horizontally or vertically on the bottom layer then have your parts and jumpers running the opposite direction on the top layer. The ExpressPCB software does not have the capability of flipping a board to view it from the bottom, because regular two-layer PCBs are always viewed "straight-through" from the top.

There is a simple solution to this problem — just print out the top view in ExpressPCB, then use the standard Windows Print-Screen function (Alt-PrintScrn) to copy the active window and paste it into the Paint accessory where you can flip the image and print out the bottom view.

The second option for computerized design of stripboard circuits is to use a program specifically designed for that purpose. I use a commercial package called "LochMaster" from Abacom Software (see Sources). A demo version is available on their site. LochMaster is definitely not without its quirks, however.

For example, it was originally a German program, and they apparently forgot to translate a couple of the menu items, which can be a challenge! In spite of this, LochMaster's 3-D printouts and automatic flipping of the board to view the bottom make it an excellent choice for stripboard design.

Before we begin constructing our first stripboard project, I want to mention three tools that can be helpful in this process (see Figure 2). To begin with, we need to discuss how to cut the traces where necessary on the bottom of the stripboard.

There are two different types of cuts. The first (which is much easier and therefore preferable whenever possible) is to cut a trace at a hole. This is easily accomplished with a "stripboard tool," which is nothing more than a drill bit in a plastic handle. Commercial stripboard tools are difficult to locate in the US, but you can use a 9/64 or 5/32 inch drill bit with some electrical tape wrapped around the top end to make it easier to use. A fancier version of this can be made using a sewing-thread spool as a handle.

To cut a trace at a hole, all you need to do is twirl the bit two or three times by hand until the copper trace is cut through, checking after each twirl to be sure you don't cut into the adjacent traces.

The second type of cut is more difficult and error-prone, but sometimes necessary. It involves cutting a trace between two holes, but leaving enough copper so that pins or jumpers can be soldered into each of the adjacent holes. The least error-prone way to do this is to use a small, sharp hobby knife (with good magnification) to remove a thin sliver of the trace between the two holes. If you feel brave, you can use a Dremel or other small rotary tool with a small diamond point (see

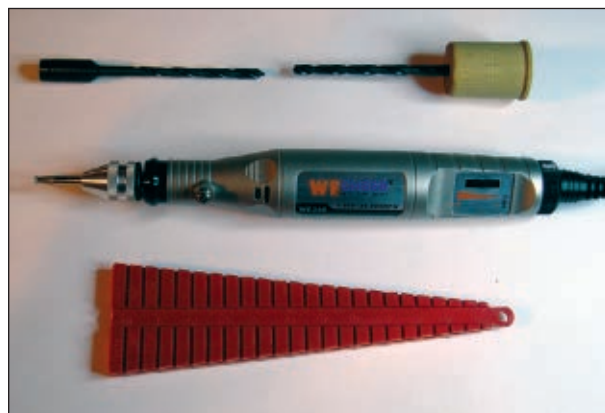
Sources) to cut through each trace. (Currently I am using a small inverted cone diamond point, but I have several other small cutting bits on order — I'll report my comparisons in a future installment of the Primer.)

Be careful — it's extremely easy to destroy a stripboard when using a power tool. (Trust me, I know!) Practice first on scrap pieces. You can also use the same small diamond points with a "micro engraver" tool such as the WeCheer WE248 (again, see Sources) shown in Figure 2. This tool is less powerful than most rotary tools, and therefore also less error-prone — but again, practice first!

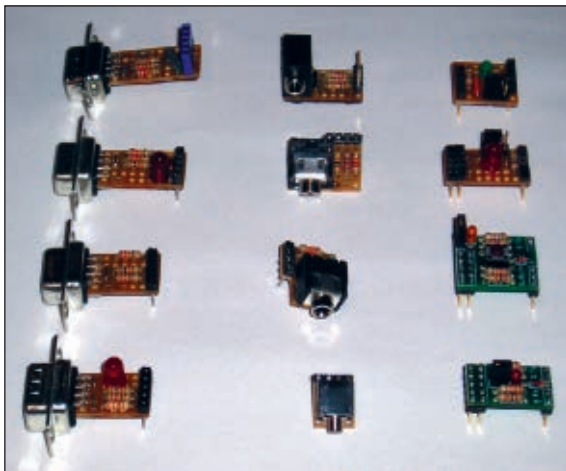
The last item shown in Figure 2 is a "lead-forming" tool, available from Jameco Electronics (Sources). This simple plastic triangle is used to bend leads and small components to size. It's not necessary, but it does speed up the process.

A STRIPBOARD-BASED PICAXE PROGRAMMING ADAPTER

For our first stripboard circuit, we're going to construct a simple programming adapter for use with any PICAXE processor. As you probably know, all PICAXE chips require the same four parts to implement the "enhanced" programming circuit: three resistors (22K, 10K, and 180 ohms) and a BAT85 diode. Of course, you can simply include these four parts in every breadboard circuit you construct, but you can save time and money in the long run by



■ FIGURE 2. Useful tools for stripboard construction.



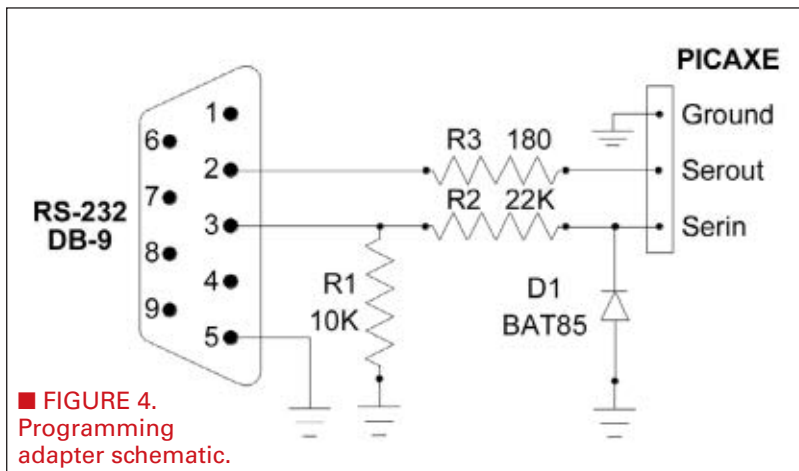
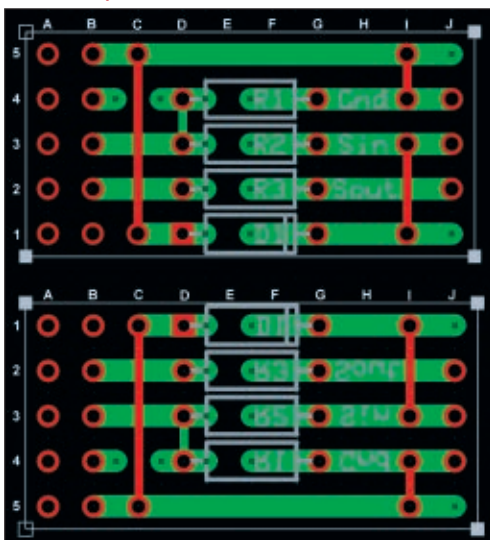
■ FIGURE 3. Various programming adapters.

constructing a separate programming adapter board that can easily be moved from project to project. Over the years, I have constructed more than a dozen variations on this theme using three different types of programming cables (see Figure 3). I began with standard DB-9 cables, next tried the PICAXE stereo-connector cable, and finally settled on using a nine- or 10-wire ribbon

■ FIGURE 5. Programming adapter parts list.

ID	Part
R1	Resistor: 10K, 1/4 W
R2	Resistor: 22K, 1/4 W
R3	Resistor: 180 ohm, 1/4 W
D1	Diode: BAT85
—	Snap Headers: Male Straight

■ FIGURE 6. ExpressPCB version of circuit layout.



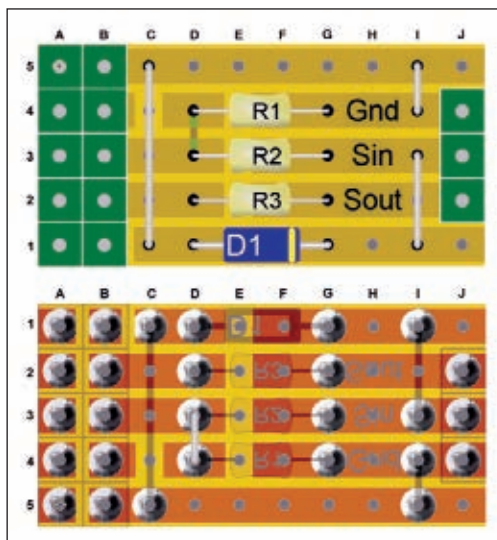
■ FIGURE 4. Programming adapter schematic.

cable and IDC connectors.

I chose this approach for two reasons: a ribbon cable can be easily constructed without soldering or crimping (both of which are time-consuming and error-prone), and a 5X2 IDC connector is easy to use with both breadboard and stripboard circuits. If you aren't familiar with this type of cable, there is a detailed description of how to construct one on my website (www.JRHackett.net/cable.htm). Figure 4 shows the schematic of the enhanced PICAXE programming circuit and the necessary parts are listed in Figure 5. (A complete parts kit for the project is available on my website.) The ExpressPCB printout (top and bottom view) for the stripboard version of the programming circuit is presented in Figure 6; Figure 7 has the stripboard master printout of the same circuit. In order to facilitate the

following discussion of the circuit's construction, I have labeled each of these printouts similarly to a typical spreadsheet: the columns are labeled alphabetically and the rows are labeled numerically. Note that I have reversed the usual numerical sequence of the rows. I did that to make the numbering correspond to the standard DB-9 pinout as it appears at the 5X2 IDC connector at the end of my programming cable.

Before you actually start construction of the programming adapter stripboard, you may want to cut a small piece of stripboard to practice a few cuts of both types on. You can put the board in a vise (protecting the traces with a cardboard or wood spacer) and cut it with a hacksaw or use a small band saw if you have access to one. I generally cut boards right in line with a row (or column) of holes and then smooth the edges with a small bench-top belt sander, but you can also use a file or sanding block. Even if you do make an irreparable mistake on the programming adapter board, it's small so it doesn't take a lot of time to start over (and it does get much easier with practice). One point is worth noting before you begin: Because the insulation tends to melt on short jumpers, all the jumpers on the board are bare (you can leave the insulation on if you



■ FIGURE 7. Stripboard master version of circuit layout.

prefer). Also, since there are only three jumpers, you can bend them by hand with a small pair of needle-nosed pliers. However, as you become more involved with strip-board circuits, you may want to purchase the simple lead-forming tool mentioned earlier. We are finally ready to begin constructing the actual circuit. The following list of directions may seem a little daunting, but I think more detail is better than less, at least at first.

- 1) Cut a stripboard to the required size (five traces of 10 holes each) and smooth the edges.
- 2) Use a stripboard tool to cut the traces at the following holes: C4, E1, E2, E3, and E4.
- 3) Use a hobby knife or rotary tool to cut all five traces between columns A and B.
- 4) Similarly, cut the trace between holes B1 and C1.
- 5) Use an abrasive plastic pad to clean all traces on the bottom of the board.
- 6) Install bare jumper wires on top of the board between C1 and C5, I1 and I3, and I4 and I5.
- 7) Solder and snip the leads.
- 8) Install diode D1. Observe correct polarity (i.e., the cathode points away from ground).
- 9) Solder and snip the leads.
- 10) Insert resistors R1, R2, and R3.
- 11) Bend the R1 lead from D4 to the R2 lead at D3.
- 12) Snip the R1 lead so that it just touches the R2 lead at D3. Be sure they are making contact.
- 13) Solder and snip the leads.
- 14) Sand or file the bottom of the board to remove all sharp protrusions.

■ **FIGURE 8.** Stripboard mounted on breadboard for soldering.

15) From the top of the board, insert the long ends of all pin headers.

16) Invert the board and insert the short ends of the pin headers into a breadboard for support, as shown in Figure 8.

17) Solder the long header pins to the bottom of the board.

18) Remove the stripboard from the breadboard.

19) Inspect the stripboard carefully for accidental solder connections and other problems.

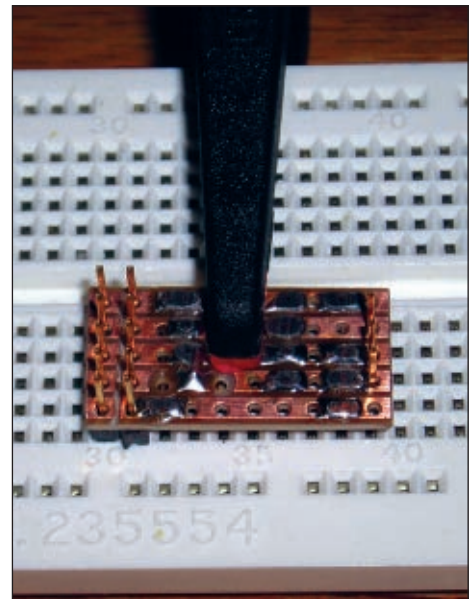
20) Use flux remover or paint thinner and an old toothbrush to clean the stripboard.

21) Allow the stripboard to dry thoroughly before testing.

Figure 9 shows the bottom of my stripboard after I completed Step 4. As you can see, I didn't make a very straight cut between the holes of column A and B, especially between holes A3 and B3. In spite of this, the board soldered fine and worked right away, so you don't need to worry about minor inaccuracies, as long as there is enough copper left around a hole to which the solder can adhere. You can either snip off the short header pin sections that protrude from the top of the board or leave them on. If you leave them on, they provide handy connections for test clips. If you snip them off and file the cut ends smooth, it's easier to insert the board into a breadboard without stabbing yourself — the choice is yours.

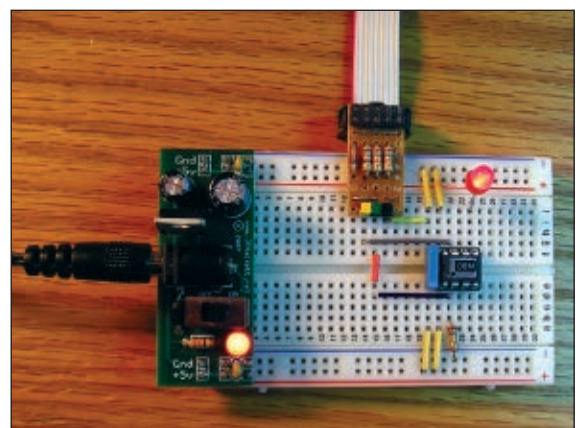
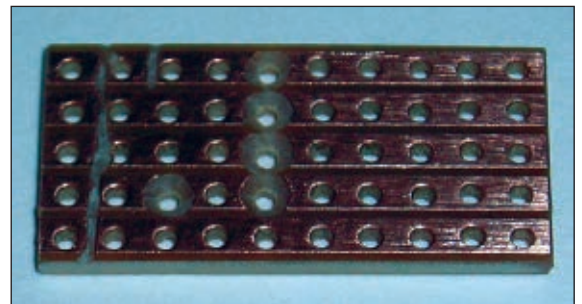
Figure 10 shows the completed programming

■ **FIGURE 10.** Completed programming adapter.



adapter installed on a breadboard as part of a simple test circuit. One aspect of Figure 10 requires explanation, namely the (100K) resistor, which is tying the 08M's Serin pin to ground. In order for any PICAXE chip to execute a program, the Serin pin must be tied to ground. Resistors R1 and R2 in the programming circuit normally do the job, but if you remove the

■ **FIGURE 9.** Bottom of stripboard after cutting traces.



Input Projects

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Output Projects

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High-Power Output
LCD Display (parallel interface)
LCD Display (serial interface)
LED Display (four-digit, seven-segment)

programming circuit (which is exactly what we want to be able to do), the Serin pin is floating and your program will not run. Therefore, I added the 100K resistor so that the circuit can function correctly in the absence of the programming adapter.

You have probably noticed that the stripboard could be one column shorter. I originally intended to label the three-pin header in column H, but the print turned out to be too small for me to read, so I opted instead to color-code the tops of the three pins: Ground, of course, is black, and I have always needed the help of mnemonic devices, so Serial In is green (because it's "in" to be green nowadays), and Serial Out is yellow (because you "yell" out) — it works for me!

SO, WHERE ARE WE GOING, ANYWAY?

If you have been reading the

SOURCES

Diamond Points
www.foredom.com

ExpressPCB Software
www.expresspcb.com

Lead-forming Tool (part #106884CJ)
www.jameco.com

LochMaster Software
www.abacom-online.de/UK/html/lochmaster.html

PICAXE-28X1
www.phanderson.com/picaxe

Stripboard and Project Parts-Kit
www.JRHackett.net/orderparts.htm

WeCheer WE248 Micro Engraver
(part #1540115)
www.texaswoodcarvers.com/Tool_Catalog/Wecheer.htm

Primer since the first installment, you now have a basic idea of just how easy and inexpensive PICAXE-based projects can be. PICAXE chips — especially the 08M and the 14M (to which we will soon turn our attention) — are excellent choices to implement simple projects and dedicated I/O peripherals for larger and more complicated projects involving a "master" processor. This approach makes it relatively easy to design and implement projects that would otherwise be impossible, or very difficult at best.

For example, the infrared input function from the previous installment of the Primer would be difficult to implement in a more complex project using only one microprocessor, due to the fact that executing an infrain2 command causes the 08M to stop and just wait to receive an infrared signal. A flexible solution to this problem is to program an 08M as a slave processor that simply waits to receive an infrared command and then relays the command to a master processor in the larger project.

This "divide and conquer" approach has three major benefits. First, it greatly simplifies program complexity because the master processor is not involved in the programming details of the specific I/O function, e.g., IR reception. Second, the debugging process is much easier because the I/O function is separate from the main program and can be completely debugged on its own. Finally, this approach can save both time and money because we end up with reusable hardware-software I/O modules.

For example, once we develop a serialized LCD display using an inexpensive parallel LCD module and a 14M processor (which we will do in an upcoming installment of the Primer), we can simply move the

■ FIGURE 11. Future PICAXE Primer I/O projects.

display from one project to another as needed, without having to re-invent the wheel (or pay for it twice).

With this in mind, I have a plan for the next several Primers. First, in the next installment we are going to implement a master-processor circuit based on the 28X1 chip. The recently released 28X1 and 40X1 are the most powerful PICAXE processors to date (although a 28X2 and 40X2 are already in the works).

We will use our master processor circuit to interface with a wide array of I/O projects; it will be an enduring part of our explorations for the remainder of this year and all of next year. If you want to purchase a 28X1 chip and get a jump-start on this ongoing project, check out the Sources.

Once we have a basic understanding of some of the features of the 28X1, we will move on to develop several I/O devices. Some of them will be 08M based, some will be 14M based, and some will need no co-processor at all. All of the processor-based I/O circuits will be designed to be stand-alone devices that can easily be moved from project to project as the need arises, and some of them will require the specific pinout of the programming adapter we just completed.

In addition, we will explore the use of the built-in I²C commands for interfacing with a real time clock and an external EEPROM for data storage. Figure 11 presents a tentative list of the I/O circuits I have in mind, but this list is not etched in stone. I am very interested in your feedback as to other possibilities you would like to have included — just email me at Ron@JRHackett.net with your ideas.

A second enduring feature of the Primer will be the continued use of stripboard circuits to make some of our I/O devices more readily reusable. In fact, next time we will construct two very useful stripboard circuits. One of them — at 0.08 sq. in. — may well be the smallest stripboard circuit in the universe — see if you can figure out what it might be! See you next time ... **NV**

Here's everything you need to harness the power of PICAXE — the inexpensive yet versatile chip that's taken the electronics community by storm. This beginner-friendly guide from IT pro and PICAXE expert David Lincoln shows you just what Revolution Education's PICAXE can do — and helps you make it do it! Packed with ready-to-build projects for all the flavors of PICAXE, the guide provides step-by-step help that's ideal for those just starting out with microcontrollers but also takes more experienced programmers where they need to go fast. Even programming neophytes can follow the clearly illustrated, learn-as-you-go instructions!

Be sure and visit the Nuts & Volts forum for discussions on various PICAXE topics!

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2.6 KERNEL

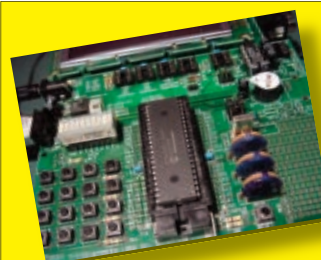
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Lemos International — as the North American distributors of Telegesis products — is excited to announce that the UK ZigBee specialists' module product range has successfully achieved certification based upon the ZigBee PRO feature set of the ZigBee standard. The widely acclaimed Telegesis AT Command layer has been tested by US test house National Technical Systems, Inc., at their Culver City laboratories in California, where Telegesis was granted ZigBee certification for their Manufacturer Specific

Profile (MSP). This makes the Telegesis ETRX2 the world's first ZigBee PRO compliant module.

All Telegesis ZigBee PRO products are built around the Ember EM250 chip with core mesh networking technology provided by Ember Corporation's EmberZnet 3.1 software. EmberZnet PRO 3.1 was the first ZigBee software to support the ZigBee PRO Feature Set and it was one of three platforms to be granted a "Golden Unit" status by the ZigBee Alliance.

Telegesis released their ZigBee PRO compliant products to beta customers during February 2008 with the whole Telegesis ZigBee PRO range expected to be generally available soon.

Speed Traps Worldwide Shown With Online Mapping Tool



Njection.com — an interactive website for the driving community — is working on exporting 50-thousand speed traps to GPS-enabled mobile phones and devices.

Utilizing Microsoft Live Maps, the Speed Trap Mashup on the website allows users to rapidly access speed trap information by country, state, city, zip code, or address, and if any are missing, speed traps can be added anonymously by anyone. Zooming in on local speed traps provides detailed information such as the type of speed detection used, posted speed limit, rating, and level of enforcement. You can even access the map for real-time local traffic info. Njection's next step is exporting this data to mobile devices with GPS capabilities.

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"Smile Shutter" Guarantees Smiles Every Time

FotoNation (www.fotonation.com), a provider of embedded imaging solutions for the imaging industry, had developed "SmileCheck," a new technology to detect smiles in portrait photos taken by digital cameras and camera phones. The new technology debuted earlier this year.

By monitoring the video preview stream in the cameras during framing, SmileCheck first looks for faces in the scene of the photo. Once faces are detected, the software looks for facial features associated with smiles. SmileCheck enables a new type of picture-taking mode called "Smile Shutter" in digital cameras. Once the camera's trigger button is depressed, the shutter is not engaged until smiles are detected on all faces within the frame, ensuring photos with all smiles. (Now you can make your security system say "cheese" to an intruder!)

Mouser Adds 64 Suppliers in 2007

Mouser Electronics, Inc., known for its rapid introduction of the newest products, has significantly expanded its linecard by signing 64 suppliers in 2007. With an already extensive portfolio of products across the board, the added suppliers bolster the product choices for Mouser's unique designed customer base. The additional manufacturers represent all the major electronic product categories including semiconductors, embedded modules, optoelectronics, passives, interconnects, electromechanical, and power.

Mouser Electronics is the only major distributor to publish a new 1,900+ page print catalog every 90 days. In addition, its website with interactive online catalog is updated daily, contains more than 900,000 products for easy online purchase, provides over 1.5 million cross-references, as well as more than 677,000 downloadable datasheets, supplier-specific reference designs, application notes, and other technical design information. For more information, visit www.mouser.com.



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Even if the ZVN4306G has a body diode (it probably does), it is good practice to place a more robust diode like the fast recovery 1N5189 across the MOSFET drain and source when driving inductive loads.

The 10K resistor is a holdover from my programming of CNC control circuits. The 10K resistor makes sure that the MOSFET is turned off if anything happens to open up the MOSFET gate drive circuitry that would allow the MOSFET gate to float and possibly activate the load. Machinists like their fingers and this is just one more way of making sure they keep them. The circuit will work just fine without the resistor.

The 1N5189 is there to form a path for the reverse voltage generated by the collapsing magnetic field. However, the UDK2559 is not based on MOSFETs with integral body diodes. The UDK2559 has bipolar transistor outputs that have a reverse-biased diode connected from their collectors to the positive power rail. Even though the diodes are internal to the UDK2559, the UDK2559 diodes are not body diodes as found within MOSFETs and are intended to do the job of the 1N5189 I used with the MOSFET driver. Hopefully, that answers your questions. Again, Judy, thank you very much for taking your time to read *Design Cycle*.

— Fred Eady

DIFFERENT VIEWS WITH HDTV

I enjoyed Jeff Mazur's article on HDTV in the December '07 issue of *Nuts & Volts*, but (there's always one of those, isn't there?) think you might have been the victim of "editorial help" in the example given for the NTSC 4:3 viewing distance.

I believe four times the screen size (diagonal size) is thought to be the distance at which a person with 20/20 vision obtains maximum resolution without being distracted by individually resolvable scan lines. This is roughly supported by normal visual acuity as follows:

A person with 20/20 vision can resolve approximately one minute of

arc at the fovea (the central, high resolution part of the eye). If we say the picture is 480 pixels (vertical) by 640 pixels (horizontal), this means the angle from top to bottom of the screen should be eight degrees or so at the eye (the small angle allows us to not have to account for the change in angle from the top or bottom of the screen to the middle). This corresponds to a distance of 7.2 times the height of the screen, which is determined by taking one half the inverse of $\tan(\text{four degrees})$; essentially one half divided by the tangent of one half the total angle. Since the ratio of the height of the screen to the diagonal is 0.6, when we multiply 7.2×0.6 we get about 4.3. Since the pixels are square, the horizontal resolution works out to give the same distance. (In this case, the angle at the eye is 10.7 degrees, the ratio of the horizontal to the diagonal is 0.8, and we have $0.8 \times (1/\tan(5.35 \text{ degrees}))/2 = 4.3$.)

In truth, of course, the actual resolution at the screen is more like 350 (vertical) by 470 (horizontal) because of various factors, so with most video content you could increase the distance to a factor of approximately six before you lose too much usable resolution. This leads to the generally accepted range of four to six times the diagonal screen size for NTSC 4:3 video.

In the examples for HDTV, I believe the article is right on; 1.5 to 2.5 times the diagonal picture size is, I believe, the generally accepted distance for optimum viewing. Using the same approach (again, since the pixels are square, either vertical or horizontal can be used), 1080 (i or p) gives about 1.5, and 720p gives 2.3. Real content usually has lower resolution, so 1.5 to 2.5 the diagonal screen size is just right. There are other considerations mentioned in the article that also influence the optimum distance from the screen to the viewer; more of these with HDTV than with NTSC 4:3. I know this is a nit, and with the aim of the article being to inform people about HDTV,

any small differences of opinion about NTSC 4:3 become even more negligible. It's just one of those things that kind of triggers an automatic email. (Lucky you.) Thanks again for an enjoyable article.

Dwight Divine (Indialantic, FL)

I'm glad you enjoyed my article on HDTV and thanks for your comments on recommended viewing distances. For the most part, your logic and math is absolutely correct. However, the assumption of normal visual acuity being one minute of arc is not always accurate. True, this figure is often used when determining 20/20 vision by viewing a printed or projected eye chart.

However, many other factors such as contrast ratio and display technology also affect one's ability to discern fine details. For most of television's history, we only considered analog CRT displays and the usual practice was to express a viewing ratio determined as the viewing distance divided by the picture height.

Quoting from Andrew Inglis and Arch Luther in the second edition of *Video Engineering* (McGraw-Hill, 1996), "Visual acuity varies widely, as much as from 0.5' to 5' (minutes of arc), depending on the contrast ratio and the keenness of the individual's vision. An acuity of 1.7' is often assumed in the design of television systems." If you substitute this value for normal acuity, you'll get a number close to my stated "standard rule."

One might also argue that CRTs do not have "square pixels;" indeed the resolution of Standard Definition digital video (ITU-R BT.601) in the US is 720x486 using non-square pixels. Having said all this, however, we now have to deal with many other display technologies, resolutions, contrast ratios, and compression artifacts. I believe all of these make it very hard to come up with a simple rule for SD or HD. But we need to offer some advice, at least as a starting point.

— Jeff Mazur

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CURRENT THOUGHTS

In Q & A in the January '08 issue of *Nuts & Volts*, Charles Rhines asks about calculating transformer current in a power supply. Transformer current ratings are in RMS amps because the ratio of DC current to RMS current is different for different rectifier circuits. You could build the power supply and use a true RMS meter to measure the current, but this is a backwards approach to the problem. Fortunately, several transformer manufacturers and others have done this and published ratios of the DC output current to the transformer RMS current for the different rectifier circuits. Mr. Rhines refers to TJ Byers answer to another question, where these ratios were not given. Earlier, in Q & A in January '06, TJ did publish these current ratios, and several readers did not agree with them. Here is an email TJ sent me:

"Thank you for the kind remarks — and being the only reader who, so far, agrees with my numbers. Too many readers are taking their numbers from a Sam's book that doesn't take into account the surge current of the input capacitor at full load." Later, TJ sent me the ratios from the book *Reference Data for Radio Engineers*, Sixth Edition, Howard W. Sams and Co., 1977, Table 3, page 146, and the ratios in the book were nearly the same as the ratios TJ had published, but given in a different way!

I have also found ratios from five transformer manufacturers (Stancor, ATC-Frost, Signal, Hammond, and MCI) and three other sources and there is very close agreement between all of them. For the "full-wave" (or "full-wave center-tap") rectifier shown in Figure 2 of Russell Kincaid's answer, five of the sources say that the DC output current should be multiplied by 1.2 to get the minimum transformer RMS current rating; the other three say to multiply by 1.0. For a "bridge" ("full-wave bridge") rectifier, the same five sources say to multiply the DC current by 1.8; the other three by 1.6.

Personally, I prefer to use 1.2 and 1.8, to provide an additional safety factor. (There have been a lot of circuits published where the transformer ratings were smaller than these ratios, including one of mine, in "Charge-It!", *Popular Electronics*, November 1997.) Also in the January '08 issue, Gerard Fonte's article "Basic Analog Power Supply Design — Part 2" begins on

page 60. In Figure 4, the rating of transformer T1 is 1.0-1.5 amps. From the ratios above, for a DC output current of one amp, the transformer rating should be 1.6 to 1.8 amps. Also, for reducing the output voltage, switch SW1 selects either half or all of the secondary of T1. As Mr. Fonte says in Part 1, a bridge rectifier has more efficient transformer usage than

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READER FEEDBACK

does a full-wave (center-tap) rectifier. However, a full-wave rectifier using all of the secondary is more efficient than a bridge rectifier using only half of the secondary. Therefore, I would use the attached circuit of Figure A to select high or low output voltage. In the high position this is a (full-wave) bridge rectifier; in the low position, a full-wave (center-tap) rectifier. Using a ratio of 1.2, the maximum current from a 1.8 amp transformer is 1.5 DC amps in the low position. If you limit the current to one amp, transformer heating and power loss will be reduced, compared to using half of the secondary winding with a bridge rectifier.

In this circuit, D5 protects U2 against reverse voltage, but there is no protection for U1. I would move the cathode of D5 from pin 3 of U2 to pin 3 of U1. I am also unsure about the ratings of R5. Assume you want a current limit of 1.0 amps. This

would require R5 to be set to 0.25 ohms. The power is only 1/4 watt, but it is concentrated in a very small part of the resistance element of R5. I think I would use a 100 ohm, five watt pot (Mouser 313-2401F-100 or Jameco 140514). The lowest current limit setting would be about 12 mA. I have built similar current-limit circuits, using six or seven fixed resistors selected by a rotary switch. The formula for the resistors is: $R = 1.25 / I$, where I is the desired limit current in amperes.

Using D7 and D8 is an ingenious way of getting an output voltage down to near zero. There is a slight loss of regulation, as the voltage drop varies from 1.0 to 1.4 V with varying current. Returning the bottom end of R6 to -1.25V instead of ground would give better regulation, but there is no

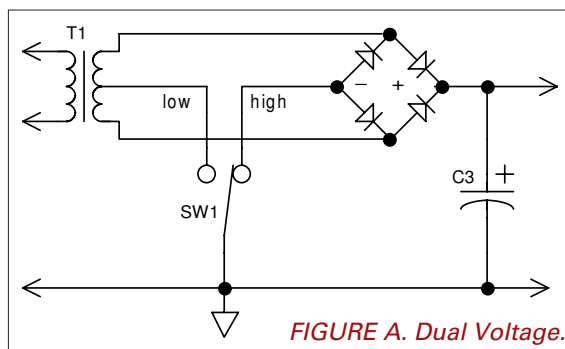


FIGURE A. Dual Voltage.

convenient way of getting -1.25V.

Bill Stiles

PUT A CRIMP IN YOUR STYLE

Regarding the December '07 article, "Model Railroad Crossing Signal," page 56, photo 2, author Paul Florian mentions connecting the sensors to the main circuit board using "female crimp housing connectors." In the photo, these look like a fantastic idea that I could use in my own projects!



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However, they are completely omitted from the Parts List, and I do not recall seeing that term used in my Digi-Key or Mouser catalogs. Could you give me some advice as to a source, and if perhaps they are more commonly known in the electronic supply catalogs by a different name?

Judy May, W1ORO (Union, KY)

The female crimp housing (three pos) part number is a Molex .100 connector with a Mouser P/N 538-22-01-2037. The Molex crimp terminals (22-30 gauge, tin) have a Mouser P/N of 538-08-50-0114. I believe Jameco has just recently stocked these parts (or equivalent). It takes some practice to use these connectors.

First, strip about 3/16" from the end of the wire. If the wire is stranded, twist the strands together. Next, I have found it useful to crimp the wire in the connector with needlenose pliers. Then, finish the crimping with a small

pair of pliers so that the crimp tabs secure the wire. Order plenty of crimp terminals as it will take some practice to get the process right. Happy Crimping!

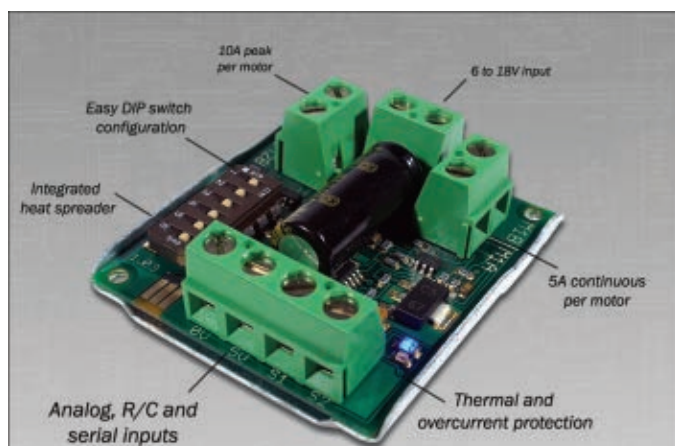
— Paul Florian

SHEDDING LIGHT ON THE LED

Near the end of Mr. Fonte's article on "Basic Analog Power Supply Design" when he calculates turn-on surge current through the bridge rectifier diodes, well I think it's messed up. He calculates the inrush current as 42 amps and then goes on to say that the worst case is 21 amps because there are two diodes carrying the current. These two diodes when in conduction are in series not parallel; the current does not divide by two. Parallel diodes may not divide the current equally, anyway. Also, I don't agree with an LED on the primary side. If you do the math, you would need about a two-watt resistor to support

this design. If you do need an LED on the primary side (I would put it on the secondary side after the bridge rectifier), I would do it this way: Put the 1N4004 in parallel but reversed (anode to cathode and cathode to anode) which would actually protect the LED from exceeding its PIV; replace the 10K with something much lower (you need a little resistance) and put a capacitor about 0.1 to 0.33 μF or so in series with the resistor (let the capacitive reactance limit the current and minimize the waste heat). Lastly, I think a 1N4004 diode in series with an LED is a poor PIV protection scheme. You are counting on the 1N4004 having no reverse leakage current or just low enough to not damage the LED. All diodes have some leakage; relying on it not to leak for the protection of the LED (which has a low PIV) is not a good design. If you need primary side indication, use the neon.

Alex Dell



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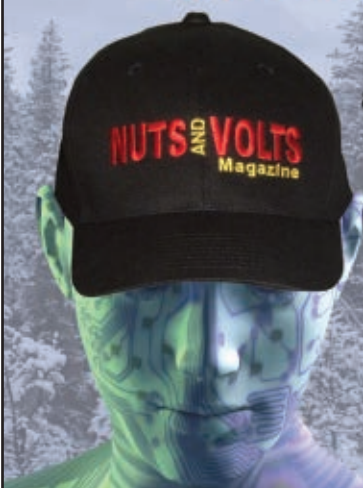
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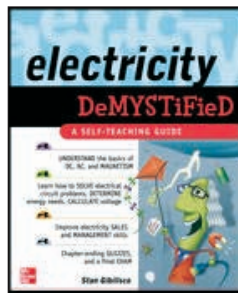
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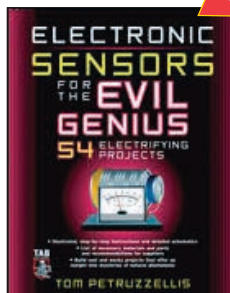
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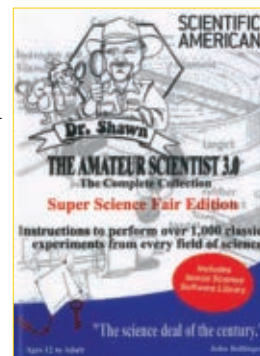
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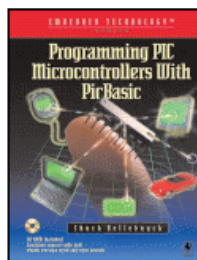
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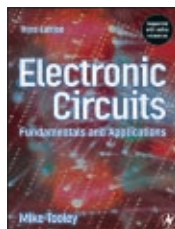


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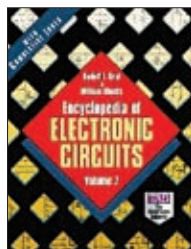
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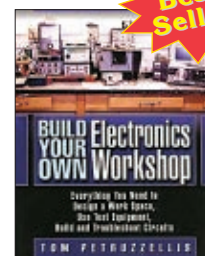
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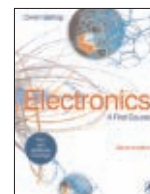
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PIC Microcontroller Project Book by John Iovine

The PIC microcontroller is enormously popular both in the US and abroad. The electronics hobbyist market has become more sophisticated. This new edition is fully updated and revised to include detailed directions on using both versions of the microcontroller; with no-nonsense recommendations on which is better served in different situations.

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Programming the PIC Microcontroller with MBASIC by Jack Smith

No microcontroller is of any use without software to make it perform useful functions. This comprehensive reference focuses on designing with Microchip's mid-range PIC line using MBASIC, a powerful but easy to learn programming language. It illustrates MBASIC's abilities through a series of design examples, beginning with simple PIC-based projects and proceeding through more advanced designs.

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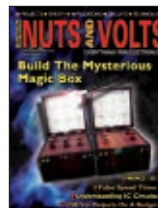
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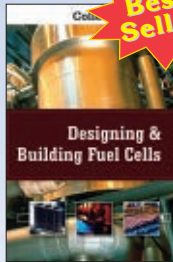


ALTERNATIVE ENERGY SECTION



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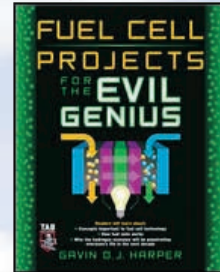
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Publish Date: October 23, 2006

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Energy Technology and Directions for the Future by John R. Fanchi

Publish Date: January 26, 2004

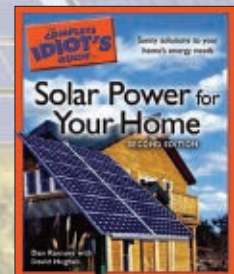
This book is a survey of energy sources that will be available for use in the 21st century energy mix. You will learn about the history and science of several energy sources, as well as the technology and social significance of energy. The book includes geothermal energy, fossil fuels, solar energy, nuclear energy, alternate energy and society, energy and the environment, sustainable development, the hydrogen economy, and energy forecasting. **72.95***



The Complete Idiot's Guide to Solar Power for Your Home

by Dan Ramsey / David Hughes
Publish Date: May 2007

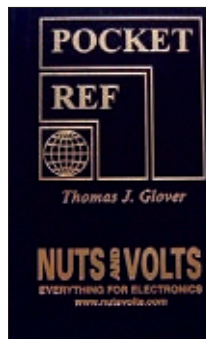
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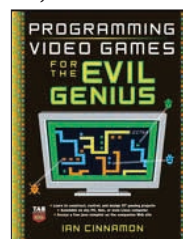
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Programming Video Games for the Evil Genius

by Ian Cinnamon
Publish Date: Feb 20, 2008

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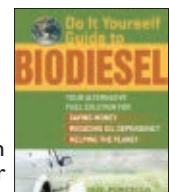
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Do It Yourself Guide to Biodiesel by Guy Purcella

Publish Date: October 28, 2007

Containing the most current and complete information available for would-be biodiesel makers, *Do-It-Yourself Guide to Biodiesel* offers a step-by-step path from the initial desire to do something good for the environment to the final stage of filling the tank with low-cost fuel. As the author tells how to break free from the grip of big oil, he counters the common myths about biodiesel with facts from university studies and his own extensive experience. **\$15.95**





TECH



FORUM

This is a READER-TO-READER Column.

All questions *AND* answers are submitted by *Nuts & Volts* readers and are intended to promote the exchange of ideas and provide assistance for solving problems of a technical nature. Questions are subject to editing and will be published on a space available basis if deemed suitable by the publisher. Answers are submitted by readers and **NO GUARANTEES WHATSOEVER** are made by the publisher. The implementation of any answer printed in this column may require varying degrees of technical experience and should only be attempted by qualified individuals. Always use common sense and good judgement!

All questions and answers should be sent by email to forum@nutsvolts.com All *diagrams* should be computer generated and sent with your submission as an attachment.

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To be considered, all questions should relate to one or more of the following:

- ① Circuit Design
- ② Electronic Theory
- ③ Problem Solving
- ④ Other Similar Topics

■ Be brief but include all pertinent information. If no one knows what you're asking, you won't get any response (and we probably won't print it either).

■ Include your Name, Address, Phone Number, and email. Only your Name, City, and State will be published with the question, but we may need to contact you.

■ No questions will be accepted that offer equipment for sale or equipment wanted to buy.

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ANSWERS

■ Include in the subject line of your email, the question number that appears directly below the question you are responding to.

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>>> QUESTIONS

Color LCD touch screen displays cost hundreds of dollars while you can get a used Nintendo DS with one touch screen and one static screen for under \$50 on eBay or other sources.

How can a Nintendo DS color display and touch screen be used for a PIC or PICAXE project?

#4081

Terry Cieslak
via email

I have a ROSS shortwave receiver RE8000, which has AM/FM and six long/shortwave bands.

It appears that when Ross went out of business, so went most of their schematics and documentation. I have been on the Internet to at least 40 locations, including hams, antiques, etc. Does anyone have a schematic or know where I can get information on it? I would appreciate any 8000 model range information. Also, operating data on a FSE5006 PNP transistor, same problem.

#4082

John Lippert
Menomonee Falls, WI

>>> ANSWERS

[#1086 - January 2008]

Where is the current cursor position from the mouse stored in Windows (PC) and how can it be accessed? I want to externally control

the cursor in addition to the mouse.

In VB.NET, the mouse cursor is an object of type cursor, a class defined in the System.Windows.Forms namespace — and you get to it in several different ways. The easiest is by using the Cursors class and it consists of several shared read-only properties. The ones you are interested in are:

Property	Type	Accessibility
Current	Cursor	Get/Set
Position	Point	Get/Set

There is, however, also a Control class, which includes MousePosition and Cursor.Position. The first one is read only, whereas the second one is writable.

But, you can still call the Win32 API and use GetCursor and GetCursorPos.

Calls to the BIOS are not even mentioned anymore (interrupt 33H, function 03H is get cursor position and button status). Be wary; often, Microsoft's documentation is a couple of versions behind and advertised examples do not even work (watch out for stuff like Cursor.Position and MousePosition — note the dot! — they often get me with stuff like that).

Under C++.NET you have the System::Windows::Forms namespace which also includes a cursor class, and it is stated that it is available to

all .NET languages.

**Walter Heissenberger
Hancock, NH**

[#2082 - February 2008]

I am converting a 1981 DeLorean into an electric vehicle and I need advice on building a battery charger for my series string of 13, 12 volt Deka 9A31 AGM (sealed absorbed glass

mat) batteries which are 100 Ah each. The manufacturer recommends a three stage charge cycle:

First, start with a constant current of 30 amps until the voltage of each battery reaches 14.4-14.6 volts (187.2-189.8 volts for the string).

Second, charge at a constant voltage of 14.4-14.6 volts (187.2-189.8 volts for the string) until "the current

acceptance drops by less than 0.10 amperes over a one hour period;" max time 12 hours.

Third, maintain a constant terminal voltage of 13.5 volts (175.5 volts for the string).

It would be best to have an option to operate off 110 volts when 220 volts is not available and to optionally limit the supply current so as not to

[#1083 - January 2008]

I am working on a bingo flash board. It has 75 lighted 2" x 2" segments that can be individually lit as the numbers are called. The bingo machine controller is old and unfixable, so I need a way to control the lighted board. I thought about using a PIC and a digital input pad to input the number. You could even use relays and 75 switches, but having that many wires may be a bit much.

#1 Figure 1 is an adaptation of an interesting circuit from Microchip and is well explained in their *Tips and Tricks* booklet, which came with their PicKit™ 1. It was expanded to 12

light emitting diodes (there is space for all 12, but they put only eight on the board) and the nice thing about it is that it is scalable, 12 channels at a time, using only four I/O. It uses a multiplex scheme and was intended to drive up to 12 LEDs. Figure 2 replaces the light emitting diodes with optocouplers and 12 of them can be built in one unit. U1 is an optocoupler and will provide isolation, which is desirable. The output state gets stored in C2, and Q1 and Q2 form a Schmitt trigger to turn on and off in a sharp way. A 10 ms pulse gets stretched to 180 ms and the output is continuous and not multiplexed. Q3 and Q4 form one power Darlington. Since this

circuit will need to be built quite a number of times, cost and parts count was kept to a minimum. On the PIC side, you can use just one PIC (PIC16F877) or put a small one on each board for 12 units. When you do the programming, don't get carried away as I did and make sure you turn off (HI

**Walter J Heissenberger
Hancock, NH**

#2 Well, there are a couple of approaches that come to mind here.

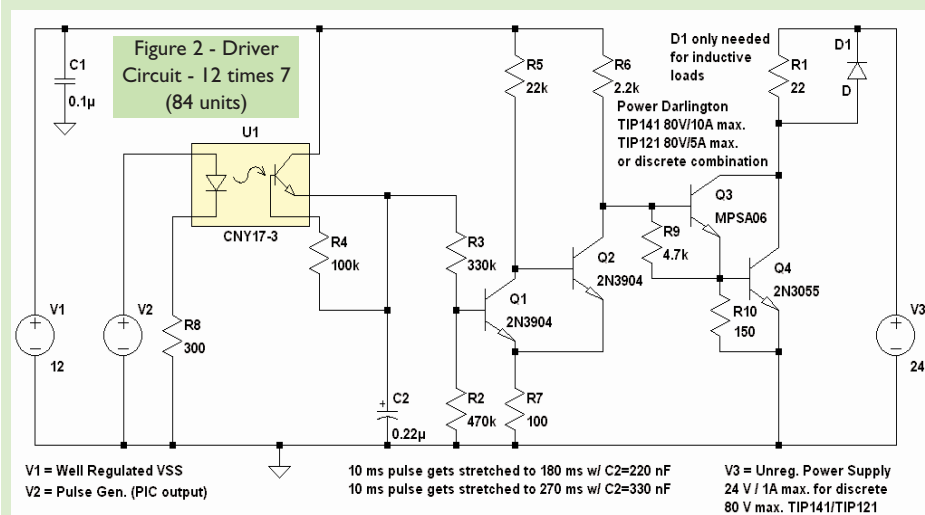
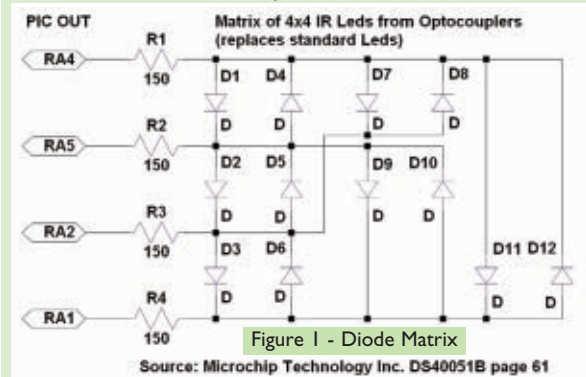
First, you could run two 25-pair phone cables from the PIC to the board, but as you say, that's kind of unwieldy.

Another option would be to run a serial cable between the 'control point' and the board, using two PICs (one at each location) and then run the 75 control wires the much shorter distance from the board controller to the board controller PIC (which you could mount inside the board, probably). The other PIC would be used for entering the numbers. (I'm assuming they don't want the PIC to pick — no pun intended! — the random bingo numbers, because if they did, all you'd need would be a single pair from the display board which would have the PIC, and the point where they push the button for a new number!)

Yet another option would be to put the PIC with the display board, and run enough wires back to the data entry point to allow for scanning the switches all the way from the display PIC.

I'd probably go for the two PIC approach.

**Rusty Carruth
Tempe, AZ**



overload a low capacity circuit breaker when charging away from home.

Ideally, it would be better to charge each battery separately so they are properly balanced, but using 13 chargers seems a bit too bulky. Any ideas?

The best way to accomplish this is through stringent monitoring of voltage, temperature, and current. Battery performance is largely a function of temperature and temperature gradient (temperature difference) across the battery itself, since it causes internal voltage differences which, in turn, causes an increase in self-discharge. Another big issue is a bad

cell from manufacturing (metal chips or other defects have been in the news lately together with "thermal" events). Therefore, monitoring the string battery by battery is essential, and equalization of temperature is equally as important.

The voltages of each battery need to be measured. One way is to use a voltage controlled current source and convert battery voltage to current (a few hundred microamps), then use a dropping resistor against ground to convert back to a voltage again and measure it with an A/D converter. Simply using a PNP 300 V TO-92 transistor and two resistors per battery can do this. Measuring a fixed voltage

with the same arrangement can compensate the temperature dependence in hardware/software.

One or two smaller converters for 10-20% (for the maximum expected difference per battery) can then equalize the charges from battery to battery. This allows using the small converters during the charge and discharge cycle, which could be a benefit, because in my experience there is always a weak cell somewhere going into reversal. This voltage reversal could be prevented as far as possible and battery life maximized. The measurement will tell you whether you are dealing with a systemic problem or one that moves

[#1082 - January 2008]

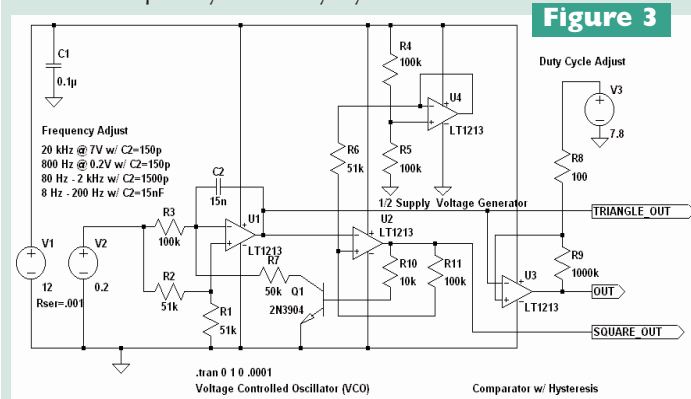
Does anyone know of a circuit that can produce pulses at a constant (but adjustable) duty cycle (around 3% or less) from 20 Hz to 20 kHz? I have seen many designs that can vary duty cycle or frequency, but not both without one affecting the other. This is for a strobe application.

#1 I'd suggest an eight pin Microchip PIC. Depending on the resolution needed, an external crystal of up to 20 MHz could be used. However, using the internal clock can get you up to 8 MHz, depending on the part. This should do fine. Then I'd hook a variable resistor voltage divider to one of the analog inputs for the duty cycle adjust. And, use a similar schema of one or two dials to set the frequency.

I know I have seen these boards available in the ads of this magazine. I think CCS has (or had one); **ccsinfo.com**.

Bill Pippin
Orlando, FL

#2 The basic principle of this circuit (figure 3) is to generate a triangular waveform (4-8 volts) with well-defined and stable upper and lower switching points. Then, a comparator uses this waveform to switch on and off at the upper part of the wave. This allows the independent adjustment of frequency and duty cycle.



U1 and U2 form a VCO (voltage controlled oscillator) with triangle and square wave output. U4 provides a 1/2 supply voltage for the VCO, and U3 is the comparator. A small amount of positive feedback is added through R9 and pulls the duty cycle adjust voltage slightly up or down to provide a small amount of hysteresis for stable switching. The LT1213 is a high speed, precision, and single supply op-amp from Linear Technology. The circuit was modeled on their Switchercad III (free), the VCO is a National Semi application, as well as the comparator (for LM324, which will only work for lower frequencies).

Another approach is to use a microcontroller with two internal timers (excellent, if crystal oscillator is used) or add another comparator to the 555 timing circuit with lower switching points, but this circuit will not be linearly adjustable.

Walter J Heissenberger
Hancock, NH

#3 A circuit with independent duty cycle and frequency control is easily created in logic hardware or coded into a microcontroller (μC). The μC is a preferred solution with much fewer hardware parts, but both operate on the same principle.

Assuming the duty cycle resolution is in one percent increments, an oscillator is used with one hundred times the desired output frequency. This can be made to adjust over the desired frequency range, and only needs to generate trigger pulses to a binary counter longer than one hundred counts (i.e., a seven stage binary counter is $2^7 = 128$).

Two digital word comparators are fed from the counter. One detects the value '100' and resets the counter while the other detects the desired duty cycle number from 1 to 99. The pulse output is taken from a latch that is reset by the first comparator (at 100 counts when the counter resets) and set by the second comparator at the count equal to the duty cycle value, thus making it a

around. It is also conceivable to provide each battery with its own small converter and automate the whole procedure. The charger you are describing is pretty standard for large lead acid batteries, such as used for electric forklift trucks. You can find further information on the International Rectifier, Allegro (power factor correction), and Microchip sites — look for reference designs.

**Walter Heissenberger
Hancock, NH**

[#2083 - February 2008]

I'm trying to interface a thermal IBM PC Compact Printer (Model 5181001) to a micro and need the tech manual or information describing the timing, commands, and pinouts of the printer. I've searched the Web, but can't locate any info other than it was used with IBM PCjr. Plenty of these printers are for sale, just no documentation that I can find.

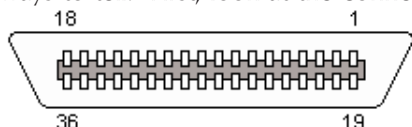
Does this printer have the same

interface as another printer that I might be able to locate?

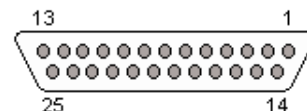
Most printers in the day of the PCjr (1984-1985) connected with either a Centronics (parallel) or RS-232 (serial) port, the parallel port being more common for printers.

According to [\[url=http://en.wikipedia.org/wiki/IBM_PCjr\]](http://en.wikipedia.org/wiki/IBM_PCjr) Wikipedia[[url](http://en.wikipedia.org/wiki/IBM_PCjr)], the IBM PCjr did not have a built-in Centronics port, only serial. According to Michael B. Brutman's [\[url=http://www.brutman.com/PCjr/pcjr.html\]](http://www.brutman.com/PCjr/pcjr.html) PCjr Page[[url](http://www.brutman.com/PCjr/pcjr.html)], the serial port was only capable of 4800 baud with 1200 baud recommended. There were, however, add-on Centronics ports.

So which one does the Compact printer have? There are a couple of ways to tell. First, look at the connect-



connector, then you have a parallel printer. If it has the RS-232 style D



connector, it is probably a serial printer.

The other thing to look for will be a small DIP switch. This may or may not have labels like Baud and/or Parity. This is a good indication that it is indeed a serial printer, especially if the labels are there.

You can find the pinouts for standard cables at www.nullmodem.com/DB-25.htm and www.nullmodem.com/Centronics.htm#parallel.

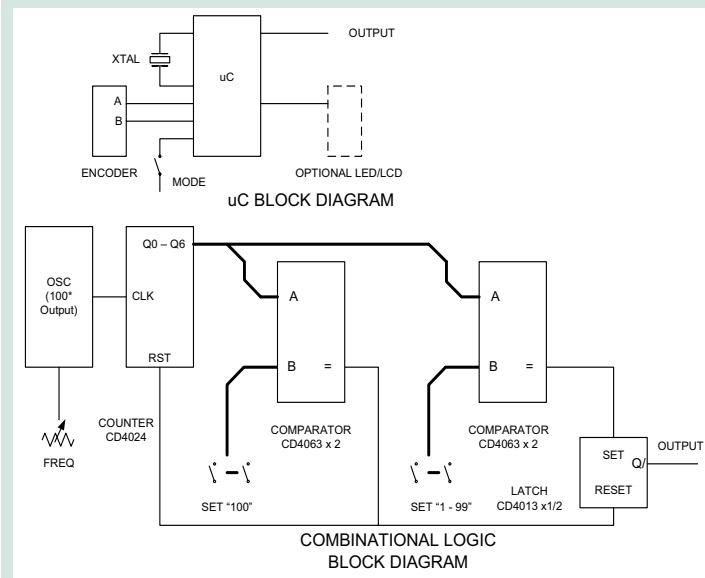
Other references:

Wikipedia IBM PCjr Page — http://en.wikipedia.org/wiki/IBM_PCjr

Mike's PCjr Page — www.brutman.com/PCjr/pcjr.html.

Further information on eBay forums (<http://forums.ebay.com/db1>

constant percentage of the total cycle time regardless of the actual operating frequency.



The same concept is easily implemented in firmware. Most entry-level μ C chips have the oscillator, timer, and memory space for user firmware that defines the counter and comparator functions. A set of binary switches (or better yet, a digital encoder) serves as the user input for both the frequency and duty cycle values. A switch selects which one is under control of the encoder. Additionally, you can add an LED or LCD to display the setting for frequency and duty cycle.

Pseudo code:

(Port set up code) 'Adapt this to a particular uC
(Timer1 set up code) 'use PortB bit 1 as output
... 'timer 100x desired output frequency

On Timer1 timer1_ISR 'jump to timer ISR each period
/*****

```
timer1_ISR:      'Timer Interrupt Service Routine
Incr count_1    'Advance counter
Case select cnt_1
Case End_cnt    'Test for count = duty-cycle data
PortB.1 = 0
Case 100        'Test for count = 100
PortB.1 = 1
count_1 = 0
End select      'Reset counter
Return
/*****
```

Main:

Enable Interrupts

Do:

Read switches

If mode_sw = 1 then

Timer1 = encoder

If mode_sw = 0 then

End_cnt = encoder

Load timer1

Loop

End

/*****

'User adjustment of frequency

'User adjustment of duty cycle

'Set timer to desired user frequency

'Continue for ever

'End Program

**Peter Stonard
Campbell, CA**

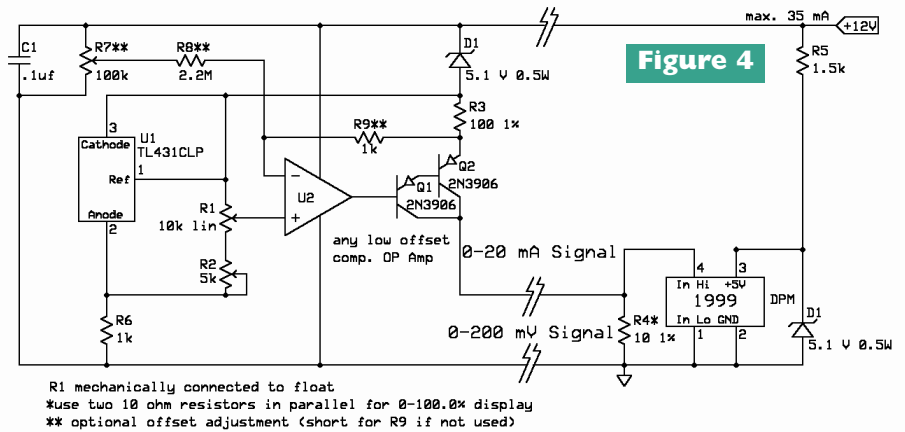
/thread.jspa?forumID=12&threadID=79002) seems to confirm that it does indeed have a serial port.

Munir Mallal
Fort Collins, CO

[#2084 - February 2008]

I need a cheap – but reliable – remote liquid level sensor setup for my home heating fuel oil tank.

#1 The circuit in Figure 4 is a three-wire remote transmitter using a 0-20 mA signal. It was chosen because it is somewhat simpler than the more common 4-20 mA solution, but requires one more wire. U1 is a low-cost 2.5 volt precision reference providing the voltage for a current source consisting of U2, Q1, Q2, and R3. Depending upon the position of R1's wiper, a current of 0-20 mA will flow through R3. Since the current gain of Q1/Q2 is large, almost the same current will flow in the collector leads (a FET/bipolar arrangement can also be used to reduce the difference further). This current is then converted back to a



REMOTE LEVEL INDICATOR

voltage and measured by a digital LCD panel meter (5V common ground type). Since a current signal is used, the length of the wire does not play a role as long as the current source does not fall out of control (in this case, the supply voltage can be increased).

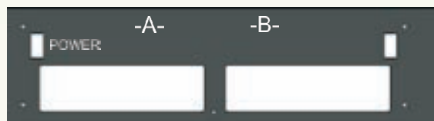
Walter J Heissenberger
Hancock, NH

#2 Please consider my method: I use an elapsed time meter connected

to the oil burner circuit to tally its run-time. I manually reset it each time my tank is "filled." Using the burn-rate of my nozzle (0.85 gph) and the capacity of my tank (550 gallons, if the meter gets to a count near 600 hours (550 divided by 0.85 = 647), I consider the tank to be nearly empty. My meter reads tenths of hours up to 100,000 hours, runs on 120 VAC, and is manually resettable. It is an old version that uses an AC clock motor to

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drive a mechanical counter and therefore rides through power outages without losing its count.

William A. Hanger
Churchville, VA

#3 The sensor LM1042 manufactured by National Instruments seems to be a solution for the application that you are proposing. The manufacturer's datasheet (www.national.com/ds/LM/LM1042.pdf#page=1) lists in addition to the specifications, some typical applications including the measurement of the oil level in a vehicle.

This sensor is listed as discontinued by National Instruments, but you can find several suppliers online by just Googling LM1042.

Albert Lozano
Shavertown, PA

[#3081 - March 2008]

I am currently working on a windmill project that uses the dynamo of a car as the generator. Can someone suggest another way or different kind

of inexpensive motor (PMDC) that will work as a generator?

Also, what charging circuit is required to charge a 12V, 40 amp battery? Any suggestions to how we can improvise our design are appreciated.

Prior to the 1960s cars used a dynamo to generate DC directly from the engine power, charge the battery, and power other 6V or 12V electrical loads. Later cars used alternators for 12V DC or (24V in trucks) that are smaller, more efficient, and have fewer moving parts. Contemporary vehicles use brushless alternators, with greater reliability, which is what you need for your windmill. A typical alternator produces 12V DC at 70 – 90amps, or about 800 to 1,000Watts. (Older 1970s alternators are limited to about 30amps, or about 400Watts). Unless you need a higher output voltage or power the modern car alternator is your best bet.

The main job of the alternator is to maintain the car battery charge, and is

controlled by the AVR (Automatic Voltage Regulator) built into modern alternators, but it could be replaced by your own design. The regulator varies the current in the field (or exciter) winding to vary the output which also changes with engine speed under driver demand. Once the engine is running the exciter and AVR are fed from the alternator output. A fully charged car battery is 13.8V so this is used to determine the end of charge and crank the alternator down to just enough to run the other electrical loads.

To implement your own controller you will need to monitor the output voltage from the alternator (including power line losses from the windmill to the battery), and feed it back to the exciter winding to maintain 13.8V at the battery. A second servo is probably required to steer your windmill into the wind and protect it from high gusts (by feathering the blades or turning it out of the wind).

Peter Stonard
Campbell, CA



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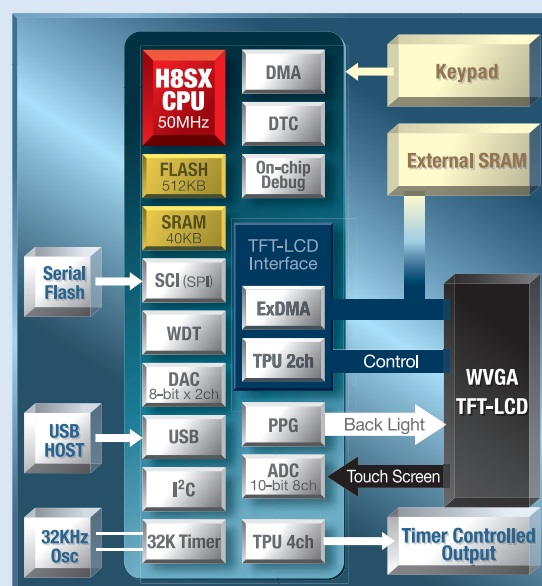
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introduces the H8SX/1600 Series with TFT-LCD Direct Drive. The performance of the H8SX at 50MHz allows panels up to WVGA size to be driven at 30 frames per second, 16-bit per pixel. The CPU/System remains available for full system operation as well as performance of complex animation. Rich on-chip peripherals perform system interface functions, reducing overall system cost.

H8SX Product Lineup

	H8S 35MHz@3v	H8SX/1600 50MHz@3v
TFT-LCD Direct Drive Roadmap	QVGA & 1/2VGA	VGA & WVGA
Refresh Rate	110/55Hz	50/30Hz
Flash Size		
1MB	120pin 144pin Coming Soon	1668R NEW 1658R NEW
768KB		1664R NEW
512KB	2378	1654R NEW 1663R NEW 1653R NEW
384KB	2374 2372	
256KB	2426 2456	
Romless		

HOT Products	H8SX/1664R
	WVGA TFT-LCD, 30Hz refresh rate, 16bpp



H8SX LCD System Features & Solutions

- Dual Data Bus System
- Parallel LCD Direct Drive
- Low Power
- CPU Bandwidth Available
- Others
 - 32-bit CISC CPU with built-in Hardware MAC. Up to 50MIPS
 - Internal and External data buses running in parallel
 - VGA panel refreshed at 50 frames per second; system at 50MHz
 - CPU core remains 90% idle during LCD drive
 - ADCs for touch screen and sensor input
 - Complex animation schemes with transparency and translucence
 - Deep Software Standby Mode (4uA) with external input wake up
 - 32KHz clock input with timer
 - Full Software API with complex LCD images supported
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*Source: Gartner (March 2007) "2006 Worldwide Microcontroller Vendor Revenue" GJ07168



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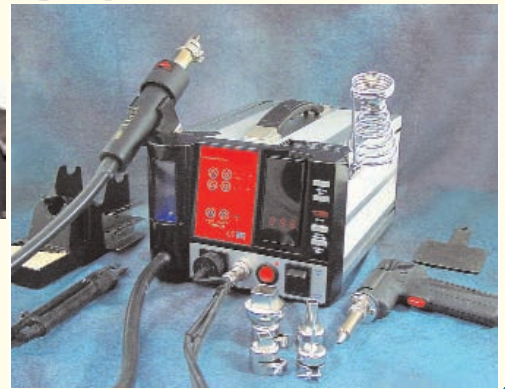
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CSI825A++

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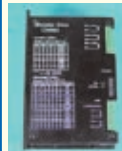
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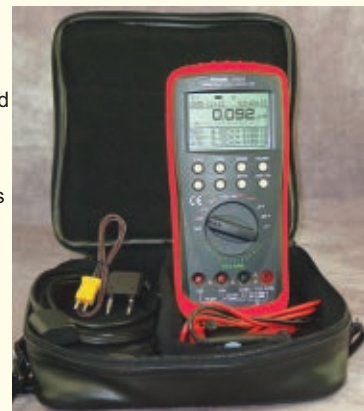
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